The analytical solution has been used to test numerical infiltration models for both periodic flux and periodic wetting conditions with good results.

H22F MC: Hall D Tuesday 1330h

Water, Energy, and Carbon Cycles in Terrestrial Systems: Three Linked Cycles at Regional to Continental Scales *(joint with A, B, T)*

Presiding: **V Lakshmi,** University of South Carolina

H22F-0396 1330h POSTER

Volatile Organic Compound Emissions Account For A Significant Part Of The Residual Net Terrestrial Carbon Sink

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Terrestrial forest ecosystems are thought to be a substantial global carbon sink. Around 120 Pg C / yr are fixed by the photosynthetic carbon dioxide assimilation of green vegetation. Nearly all of it is released again into the atmosphere by autotrophic and heterotrophic respiration. Only a small fraction, the net ecosystem productivity (NEP), is remaining for plant growth, i.e. long term storage. In addition to respiration, a substantial amount of carbon is re-emitted as volatile organic compounds (VOC). A small number as compared to primary fixation VOC emission gains significance as compared with NEP. Therefore, it is of high interest to consider these losses in carbon budget calculations. In order to assess the impact of biogenic VOC emissions on the terrestrial carbon budget we compared the VOC carbon emissions with the net ecosystem carbon gain on a midlatitude and tropical data base. The estimated numbers indicate that a substantial amount of carbon is recycled to the atmosphere, which cannot be disregarded for carbon budget calculations.

H22F-0397 1330h POSTER

Evaluating the impacts of climate variability and land management on nitrate export and crop production across the Upper Mississippi Basin

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Since the 1950s, agriculture and food production in the U.S. have become increasing dependent on the application of nitrogen fertilizers. However, the increase in N fertilizer application in the Mississippi Basin is also largely responsible for a three-fold increase in nitrate export by the Mississippi River and the growth of the hypoxic zone in the Gulf of Mexico. Variability in climate makes controlling future nitrate export, while sustaining crop production, a formidable challenge. In this study, we use the IBIS terrestrial ecosystem model and the HYDRA hydrological transport model to simulate crop yield and aquatic nitrate export in the Upper Mississippi Basin from 1974-1994, and assess the impact of a 30% change in historical N-fertilizer use.

The modeling system accurately simulates the annual and spatial variability in historical maize and soybean yields and nitrogen loading to rivers. There is strong agreement (r^2=0.77) between simulated and USGS estimated annual nitrate export by the Mississippi at Clinton, Iowa. The 30% increase in fertilizer causes only a 4% increase in mean maize yield, but a 59% increase in mean nitrate export; whereas a 30% decrease causes a 10% decrease in maize yield, but a 42% decrease in nitrate export. As fertilizer application increases, nitrogen leaching becomes increasingly sensitive to the hydrologic conditions, particularly if there is ample residual nitrogen in the soil. Therefore, controlling fertilizer application could reduce nitrate export, without significantly affecting crop yields, but will depend on climate variability and the impact of historical land use practices on soil nitrogen storage.

H22F-0398 1330h POSTER

Physiological control of carbon and water fluxes in the Chequamegon National Forest, its variability and consequences

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Stomatal function and photosynthetic capacity in the Chequamegon National Forest display much variability within and between individuals, species, seasons or years, and sites (upland forest, lowland forest, and wetland). Significant partitioning of the variability is between overstory and understory, by species, and by drought (1997). The remaining large variability on any site must be incorporated into flux models for the net carbon storage and site hydrology. Simulations with our observed ranges of Ball-Berry parameters (found to best fit stomatal behavior) and photosynthetic capacity (as Vc,max referred to 25oC) were undertaken in order to estimate (1) which of these parameters (their statistical distributions) are most important to measure accurately and (2) whether integrated fluxes of CO2 and water vapor respond linearly to parameter values and thus can be modelled with single, averaged values of parameters. We find a high flux control coefficient (0.35) for total stomatal conductance, gs, over water flux, and a weaker one near 0.10 for carbon flux, for representative summertime conditions. Stomatal response to humidity and to photosynthetic rate appears to be important, in contrast to simpler stomatal models, but the quantitative importance is seen only in those simulations that resolve distributions of irradiances on leaves rather than single average irradiances. Carbon flux is significantly and nonlinearly sensitive to variations in Ball-Berry slope m alone, but flux becomes highly insensitive when the strong negative correlation of slope with intercept b is accounted. Carbon flux remains sensitive to Vc,max25, but in linear fashion, and water flux appears linearly dependent upon both m and Vc,max25. The latter may be taken as the only two independent parameters, eliminating b. Thus, Vc,max25 seems most important for large-scale simulations with more detailed models such as SiB2. Indirect control of carbon flux by water fluxes that can lead to water stress may be as important as direct control of carbon flux, in certain years. In detailed simulations, single average values of parameters should suffice, given the linearity of fluxes. Additional field measurements indicate that photosynthetic downregulation in response to high irradiance or high leaf temperature should not be significant under almost all summertime conditions.

H22F-0399 1330h POSTER

Effects of Interannual Climate Variability on Terrestrial Ecosystem Carbon Fluxes in the Last Two Decades With Unusual Warming and ENSO Cycle

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Climate anomaly is the most important factor controlling interannual fluctuation in ecosystem carbon fluxes, which, in turn, drive most of year-to-year variations in atmospheric CO2 concentration. Therefore, understanding the dynamic responses of terrestrial ecosystem carbon cycle to climate variability should provide insight into the processes regulating the changes in atmospheric CO2. In this study, we used a dynamic biogeochemical model driven with observed changes in climate and atmospheric CO2 to quantify the changes in terrestrial ecosystem carbon fluxes between 1981 and 1998. Our results show that a clear El Ni?o Southern Oscillation - related change - net primary and ecosystem production in (NPP and NEP) decreased during El Ni?o episodes and increases in normal or La Ni?o episodes - was superimposed on the high temporal variation in terrestrial ecosystem carbon fluxes. NPP and NEP in the 1990s were significantly higher than in the 1980s, however, NEP varied greatly from year to year - the standard deviation was larger than the mean value and the seasonality was enhanced. In our estimates, the sign and magnitude of the global NEP depended largely on the climatic responses of tropical ecosystems. Our estimates also reveal that the changes in terrestrial carbon fluxes were a composite of complex effects of global climate phenomena, spatially specific climate variability, and the differential responses of various biomes.

H22F-0400 1330h POSTER

Importance of Permafrost for Water Cycle and Vegetation in East Siberian Taiga

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East Siberian taiga is a unique ecosystem, which is established on permafrost. Climate there is extremely dry (about 250mm of annual mean precipitation). Oxygen and hydrogen isotope ratios of precipitation, soil water, sap water of plants, river, surface water, and atmospheric water vapor were observed in deciduous boreal forest near Yakutsk, Russia, to investigate the water flow in the ecosystem. Isotopic composition of precipitation characteristically changed during spring from low delta value (winter) to high delta value (summer), because of the change in the isotopic composition of water vapor. Transpired water by plants, namely, recycling of water from the surface through plants, may contribute the isotopic composition of atmospheric water vapor. Stable isotope ratio of sap water in plants and soil water were different between wet summer and dry summer. Sap water delta values were high during dry summer, and low during drought. This result indicated that rain water was used by plants when plants received enough summer rain, while melt water from permafrost was taken up by plants during drought. Isotopic composition of soil water indicated that water was transported upward in the soil during dry summer, while, rain water percolated downward during wet summer. Soil has a function for a storage of water in the permafrost region, and stored water in the soil can be a direct source of water for vegetation during drought.

H22F-0401 1330h POSTER

Derived continental U.S. land surface hydrologic fluxes and state variables, 1950-2000

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Advances in macroscale land surface modeling, and rapidly improving computational capabilities, facilitate the implementation of physically realistic land surface parameterizations that represent water and energy fluxes over large areas. Evaluation of these formulations has been undertaken by recent efforts such as the GEWEX Project for Intercomparison of Land Surface Parameterizations (PILPS), and Water and Energy Budget Synthesis study (WEBS). In all such evaluations, a baseline of observations, or benchmark simulations, is needed with which simulated land surface states and fluxes can be compared. We describe a land surface data set, produced at 1/8 degree spatial resolution and 3-hourly time resolution for the period January 1950 through July 2000 suitable for such model evaluations, and for exploratory data analysis where model products can act as surrogates for unobserved variables. The data set consists of both surface hydrologic forcings derived more or less directly from observations (downward solar and longwave radiation, precipitation, temperature, relative or absolute humidity, surface wind, and surface pressure) and derived moisture and energy fluxes (runoff, evapotranspiration, reflected solar and emitted longwave radiation, sensible and ground heat flux) and state variables (surface temperature, soil moisture, and snow water storage). It covers all of North America between latitudes 25 and 53 north. Gridded precipitation and temperature are derived from NOAA Cooperative Observer daily station data disaggregated to three-hourly values, while surface humidity and radiative forcings are derived from daily temperature and temperature range. Surface wind is taken from NCEP/NCAR reanalysis. These forcing data were used to drive the Variable Infiltration Capacity (VIC) model, which solves a complete energy and water balance at each (3-hour) time step. The VIC model output is included with the forcing data as a complete set of land surface data. The data are publicly available. Exploratory analyses are summarized in which simulated runoff is compared with observations, and spatial and temporal persistence of simulated soil moisture is compared with observations at selected locations across the continental U.S.

URL: http://www.hydro.washington.edu

H22G MC: 301 Tuesday 1330h

Submarine and Subaerial Mass-Movement Processes I *(joint with OS, T)*

Presiding: **M E Reid,** U. S. Geological Survey**; P Watts,** Applied Fluids Engineering, Inc.**; H J Lee,** U. S. Geological Survey

H22G-01 1330h INVITED

Mechanical Differences Between Subaerial and Subaqueous Mass Movements

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The differing densities and compressibilities of ambient fluids in subaerial and subaqueous environments produce important differences in mass-movement mechanics. Statically, one key difference arises because subaqueous slopes generally are fully saturated with dense fluid and have constant-head boundaries along their surfaces. Constant-head boundary conditions dictate that near-surface seepage forces act normal to slopes, commonly an almost optimal direction for slope destabilization. Subaerial slopes lack this constraint on seepage-force direction as well as ubiquitous pore saturation. Therefore, pore-fluid flow produces a greater variety of effects in subaerial slopes than subaqueous ones. Static subaqueous sediment masses commonly have larger porosities than do masses of comparably textured soil on subaerial slopes, owing to buoyancy that produces low ambient effective stress during subaqueous sedimentation and consolidation. Large porosities provide enhanced potential for contractive shearing during slope failure. Contractive shearing, in conjunction with seepage forces that act normal to slopes, increases the likelihood of liquefaction and post-failure flow of landslide masses.

Flowing mass movements in subaerial and subaqueous environments respond dynamically to differing effects of buoyancy, boundary drag, and flow-front forces. Buoyancy reduces the effect of gravity on subaqueous landslide masses by about 50% (in comparison to subaerial landslides), resulting in reduced importance of Coulomb friction relative to other forms of boundary resistance, reduced efficacy of grain-size segregation, and increased tendency for sediment dilation and turbulent suspension. Flow-front dynamics, which largely dictate landslide depth, speed, and impact force, can differ markedly in subaerial and subaqueous cases. Subaerial flow fronts develop blunt, high-resistance snouts chiefly when nonuniform internal resistance is present – typically as a result of reduced pore-water pressure in coarse sediments that concentrate at flow margins. Subaqueous flow fronts can develop blunt snouts by an entirely different process, which depends on external reaction forces imposed by the dense, nearly incompressible ambient fluid that must be displaced during flow-front motion. Thus, although subaqueous and subaerial flow fronts have morphological similarities, their dynamical causes may differ.

H22G-02 1350h

Water Waves Generated by Subaerial Mass Flows

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Existing methods for modelling tsunami propagation in the "far field", that is, at great distance from the wave source, treat the water waves as dispersive and ignore details of source dynamics. This approach is commonly inapplicable when one considers subaerial mass flows entering lakes or embayments, in which case nearly the entire water body lies within the "near field," beyond the zone of complex splashing but close enough to the source that the effect of dispersion on wave shape is negligible. Scaling analysis of the equations governing water-wave propagation leads to the prediction that near-field wave amplitude depends on certain measures of mass-flow dynamics as well as on the volume of the mass flow. This prediction is confirmed by laboratory flume experiments with solid-block "landslides" and by reanalysis of previous laboratory investigations with idealized mass flows (both block landslides and grain flows). All data are well described to first order by a simple function $\eta/h = Q^{0.51}$, where η/h is near-field wave amplitude as a fraction of ambient water depth, and Q (always $<$ ca. 1) is a dimensionless measure of the volumetric rate of water displacement. Our data suggest that for $Q << 1$, there is a weak second-order dependence of on dimensionless measures of the duration of submerged landslide movement and the vertical component of impact velocity. Application of the first-order scaling relation to several historical events yields "predicted" near-field wave amplitudes in reasonable agreement with measurements. The scaling relation thus provides a prognostic tool for putting an upper bound on the near-field amplitude of water waves caused by mass flows if one has a way– perhaps using historical- or paleohydraulic evidence–to estimate the probable peak discharge. More generally, one can predict the near-field amplitude of water waves caused by mass flows if probable bounds can be put on flow volume and the duration of motion after impact. Predicted characteristics of near-field waves can be used as initial conditions in numerical models for studying wave propagation and hazards such as runup on shores and overtopping of structures.

H22G-03 1405h

Distinguishing Submarine Landslide Deposits From Migrating Sediment Wave Fields

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Migrating sediment waves have been reported in a variety of marine settings, including submarine leveefan systems, floors of fjords, and other basin or continental slopes. Examination of such wave fields reveal nine diagnostic characteristics. When these characteristics are associated with features previously attributed to submarine landslide deformation, they suggest a reinterpretation towards one of migrating sediment-wave fields. Sites for reinterpretation include wave fields in the Gulf of Cadiz, the continental shelf off the Malaspina Glacier in the Gulf of Alaska, and the Eel margin in northern California (the "Humboldt slide feature"). The reassessment of all of these sites strongly suggests that numerous turbidity currents separated by intervals of ambient hemipelagic sedimentation deposited the wave fields over thousands of years. A numerical model of hyperpycnal discharge from the Eel River, for example, shows that under certain alongshore-current conditions, hyperpycnal-flow events can produce turbidity currents that flow across the Humboldt-slide-feature, serving as the mechanism for the development of migrating sediment waves. Numerical experiments also demonstrate that where a series of turbidity currents flows across a rough seafloor, sediment waves form and migrate upslope. Hemipelagic sedimentation between turbidity current events further facilitates the upslope migration of the sediment waves. Physical modeling of turbidity currents also confirms the formation and migration of seafloor bedforms. The morphology of sediment waves generated both numerically and physically in the laboratory bears a strong resemblance to those observed in the field, and the diagnostic criteria developed should be used to distinguish sediment waves from limited-deformation landslides.

H22G-04 1420h INVITED

Instability and Tsunamigenic Potential at Convergent Margins

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Along many convergent margins multibeam echosounding navigated with GPS has revealed large slope failures that were probably tsunamigenic. Bathymetric data combined with seismic reflection imaging indicate multiple causes. The 55-km wide Nicoya Slump resulted from the steepening slope above an underthrusting seamount on the subducting oceanic plate. This slump may have generated a 27-m high wave. Several 5-7 km wide mid-slope slides off central Nicaragua probably resulted from steepening of the continental slope by tectonic erosion. They may have generated waves 6-7 m high. A 30 km wide mid-slope slump off northern Peru may have generated a 5 m high wave. Its cause will not be understood without better seismic reflection imaging but considerable fluid venting was observed across its headwall. In the Gulf of Alaska a large slide appears to have resulted from rapid sedimentation. Tsunamigenic slope failure along convergent margins is only beginning to be resolved and the causes vary. Subducted ocean floor relief, tectonically steepened slopes, and sites of rapid sedimentation can help target potential failure and possible future tsunami hazards.