with mid-latitudinal stratospheric westerly wind, like as the above laboratory experiment.

A31C-05 0935h

Dissipation of Vortex Structures in Stratified Rotating Fluids

Adam M Fincham (fincham@coriolis-legi.org)
Laboratoire des Ecoulements Gophysiques et Industriels, BP 53 Cedex 9, Grenoble 38041, France

The late time evolution of turbulence in the presence of stable density stratification leads to a state of quasi-2D vortices separated vertically by strong horizontal vortex sheets. As both the buoyancy scale u/N and the vertical velocity w approach zero the vorticity field remains highly 3D as strong vertical shearing between structures promotes a horizontal alignment of the vorticity vector, and is responsible for almost all of the viscous dissipation of energy. A new laboratory measurement technique is used to directly simulate the time evolution of these flows. This technique relies on getting the Reynolds number from the length scale while keeping the velocity small, hence providing a characteristic time scale that is sufficiently large to permit full 3D scanning through the measurement volume in a relatively short time. Full field 3D measurements of the vorticity fields associated with stratified flows with and without rotation are made. The kinetic energy budget is balanced for individual structures, 3D iso-enstrophy surfaces and vortex filament trajectories are presented. A variety of experiments involving towed grids, jets and wakes demonstrates the coupling between the internal wave and vortex fields and shows the competing effects of both stratification and rotation on the structure of these geophysical type flows.

URL: http://www.coriolis-legi.org

A31C-06 0950h

Population of Non-Wave Modes in Strongly Stratified, Rotating Flows with Unbalanced Turbulent Forcing

Leslie M Smith (608 262 3852; lsmith@math.wisc.edu)
University of Wisconsin, Department of Mathematics, Madison, WI 53706, United States

Numerical simulations are used to study the population of slow modes in rotating, stably stratified flow in the Boussinesq approximation, with rotation and stratification both in the vertical direction. Energy is injected through a three-dimensional, isotropic, white-noise forcing localized at small scales. The parameter range studied corresponds to Froude numbers smaller than an O(1) critical value below which energy is transferred to scales larger than the forcing scales ($Fr \approx 0.1$). The values of the ratio N/f range from $1/2 \leq N/f \leq \infty$.

The simulations show that, for these parameters (in a nonlinear regime), energy accumulates in the zero-frequency (non-wave) modes, or in near zero-frequency modes, *corresponding to the linear problem*: the Vertically Sheared Horizontal Flow (VSHF) modes, or the Potential Vorticity (PV) modes (please see accompanying poster presentation). For stratification dominated flows, our simulations show that the large scales generated by the turbulence are the VSHF modes. In this case, the PV modes play a secondary role, acting to inhibit the transfer of energy to large scales. On the other hand, for $1/2 \leq N/f \leq 2$, our simulations show that the inertial-gravity waves are insignificant and that the dynamics are completely dominated by the PV modes. This is quasi-geostrophic turbulence characterized by the inviscid conservation of two quadratic invariants and a $-5/3$ inverse energy cascade. The region $1/2 \leq N/f \leq 2$ is also exactly the region where resonant triad interactions cannot occur. These results suggest that $1/2 \leq N/f \leq 2$ is the domain of validity of the quasi-geostrophic model (for moderate aspect ratios), and that resonant wave interactions play an important role in the population of the slow, VSHF motions in strongly stratified flow.

A31C-07 1005h

Balanced Tropical Moisture Waves in a Mesoscale Model

Adam H Sobel[1] (212 854 6587; ahs129@columbia.edu)
Christopher S Bretherton[2] (breth@atmos.washington.edu)
[1]Columbia University Columbia University, 500 W. 120th St. Rm. 217, New York, NY 10027, United States
[2]University of Washington, Seattle, WA

We address the interaction of large-scale waves with deep convection in nonrotating mesoscale model simulations without mean vertical shear under idealized boundary conditions (doubly periodic, fixed uniform sea surface temperature). Radiative-convective feedbacks are not considered. The model is initialized with random thermal perturbations near the surface and then run for 16 days to a state of approximate radiative-convective equilibrium. At this point, a wave-like heating is imposed for one day in order to create a wave. After this single day of forcing, the heating is turned off and the wave is allowed to evolve freely for seven more days.

When the initial forcing's phase velocity equals the mean flow velocity, a balanced disturbance is produced, though one of an unfamiliar type. This wave has a large signal in the moisture field and close cancellation between adiabatic cooling and diabatic heating. This cancellation can be shown to be a form of balance in that assuming it in a systematic way eliminates gravity waves from the equations of motion. This balance, like other more well-known ones, can be viewed as a result of rapid geostrophic adjustment, but extended to a non- or weakly rotating environment. Similar balanced moisture waves have been found in previous cloud-resolving simulations and recent theoretical work. The relationship between the simulations and the theory will be discussed.

URL: http://www.columbia.edu/~ahs129/pubs.html

A31C-08 1040h INVITED

Variational Principles for Lagrangian Averaged Models in Geophysical Fluid Dynamics

Darryl D Holm (1-505-667-6398; dholm@lanl.gov)
Los Alamos National Lab , Theoretical Division, MS B284, Los Alamos, NM 87545, United States

The Lagrangian average (LA) of the ideal fluid equations preserves their fundamental transport structure. This transport structure is responsible for the Kelvin circulation theorem of the LA flow and, hence, for its potential vorticity convection and its helicity conservation.

We show that Lagrangian averaging also preserves the Euler-Poincaré (EP) variational framework that implies the exact ideal fluid equations in the Eulerian representation. This is expressed in the Lagrangian-averaged Euler-Poincaré (LAEP) theorem.

We illustrate the LAEP theorem by applying it to incompressible rotating stratified ideal fluids to derive the Lagrangian-averaged Euler (LAE) equations and thereby recover the Generalized Lagrangian Mean (GLM) motion equation. Finally, we discuss recent progress in closing these equations as models for Lagrangian averaged fluid turbulence in GFD applications such as global ocean circulation.

URL: http://xxx.lanl.gov/abs/nlin.CD/0103043

A31C-09 1100h

Rossby Index and Long Range Variability of Truncated Shallow Water Model.

David Gurarie (216-368-2857; dxg5@po.cwru.edu)
Case Western Reserve University, Math. Dep., Cleveland, OH 44106

Long-range atmospheric variability (seasonal to decadal scales) has many sources and wave-vortex interactions could play an important role. Our paper sets to explore it for a truncated shallow water model, in the spirit of E. Lorenz. One of the key features of large scale atmospheric circulation driven by zonal (Hadley-Ferrel) forcing is instability of the zonal jet and the blocking phenomena (strong near stationary anticyclones). Charney-DeVoor 1978 studies these phenomena in the context of truncated quasigeostrophy, that coupled zonal flow to simplified (wave-number 2) topography of the Northern hemisphere. They attributed transitions to stability properties of zonal and blocking equilibria in the phase-space of the truncated system, and emphasized the topographic effects. We adopt a different approach by considering shallow water model, viewed as a coupled system of potential vorticity and gravity wave modes an extension of 2D quasigeostrophy. It also exhibits zonal (high Rossby index) vs. blocking flow patterns, and we examine the underlying mechanism due to wave-vortex interaction in the system. We develop new conceptual and mathematical tools to study such phenomena and its effect on the long range climatology of shallow water.

URL: http://www-math.cwru.edu/~dxg5/paper/rsw02.pdf

A31C-10 1115h INVITED

Conditions for Legendre-Transformability of Semi-Geostrophic Theories on the Hemisphere.

James Purser (301-763-8000, x7267; jim.purser@noaa.gov)
NOAA/NCEP/EMC, W/NP2 Room 207, WWBG, 5200 Auth Road, Camp Springs, MD 20746-4304, United States

It has been shown elsewhere that a Legendre-transformable formulation of semi-geostrophic theory based on Hamilton's principle possesses some valuable properties. For example, there must exist a transformed geographical coordinate together with some additive modification of the geopotential, such that the set of allowable instantaneous solutions coincides with the set of convex functions. If this is the case, then approximating finite-element solutions provide a reliable way of investigating evolving solutions even in cases where frontal singularities spontaneously develop. It can be argued, conversely, that semi-geostrophic theories which do not possess the property of Legendre-transformability can give rise to singularities which make it no longer possible to guarantee the well-posedness of the subsequent evolution. When applying these ideas to semigeostropic theories on the curved earth we find that Legendre-transformability imposes severe limitations on the form that the dynamical theory can take. A consistent hemispheric theory of this kind, unblemished by a polar singularity has proved elusive. We comment on the significance of this apparent limitation.

A31C-11 1130h

Applications of Semi-Geostrophic Balance in the Tropics

Michael J. P. Cullen (+44 (0) 118 931 8996; M.J.P.Cullen@reading.ac.uk)
Department of Mathematics, University of Reading Whiteknights PO Box 220, Reading, Ber RG6 6AX, United Kingdom

Semi-geostrophic dynamics can describe large-scale flows, with at least one horizontal length scale larger than the deformation radius. The solutions have to be inertially stable. Results based on aircraft observations are used to show that the inertial stability condition is nearly always satisfied on a horizontal scale of 80km. Near the equator, the inertial stability condition restricts the geostrophic flow to be near-zonal. The precise restriction is calculated. It is possible that the inability to form tropical cyclones near the equator is due to the inability to generate a pre-existing balanced disturbance of sufficient amplitude to act as a trigger. Such a disturbance would violate the inertial stability condition. If standard physics is added to the semi-geostrophic model, pressure gradients at the equator can be supported in the boundary layer. It is shown how a basic thermally-driven monsoon circulation can be simulated, because the model tries to maintain zero horizontal pressure gradients in the presence of the high-level heat source over the Tibetan plateau.

A31C-12 1145h INVITED

Rupert Ford: Memories of a Young Scientist

David Ford (edford@u.washington.edu)
University of Washington, Box 352100, Seattle, WA 98195-2100, United States

From a young age Rupert Ford showed an intense and sometimes very amusing involvement in science which I hope to share with his friends and colleagues at the meeting. He was deeply engaged in his research, was an enthusiastic member of the scientific community and thought a lot about the scientific process and the role of science in the community.

A31D WCC: 15 Wednesday 0900h

Fire, Scars, and Smoke III: Biomass Burning

Presiding: **G Gutman,** NASA Headquarters**; C Justice,** University of Maryland

A31D-01 0900h INVITED

The GOFC/GOLD program: a global observation system for fires

Christopher O Justice[1] (3014051600; justice@hermes.geog.umd.edu)
Ivan A Csiszar[1] (3014058696; icsiszar@hermes.geog.umd.edu)
Jeffrey T Morisette[2] (3016146676; jmoriset@pop900.gsfc.nasa.gov)

[1]University of Maryland, Department of Geography, 2181 LeFrak Hall, College Park, MD 20742, United States

[2]NASA Goddard Space Flight Center, Code 923, Greenbelt, MD 20771, United States

There are a number of different satellite systems that are currently providing information on fire susceptibility, active fires, burned area, fire emissions and post fire recovery and a number that are being designed. Similarly, countries are collecting different information on the extent and characteristics of fires. There has been little coordination of these activities to date. With the increasing interest in global environmental change, fire hazards, trans-boundary fire impacts and changing fire regimes, there is a need to put in place the observing systems to support improved resource management, policy decision making and global change research. The GOFC/GOLD Program (Global Observation of Forest Cover/Global Observation of Landcover Dynamics), which has been developed within the Integrated Global Observing System (IGOS), provides a forum for international information exchange and observation and data coordination. The GOFC/GOLD Fire Mapping and Monitoring Theme is aimed at refining and articulating the international observation requirements and making the best possible use of fire products from the existing and future satellite observing systems. GOFC/GOLD is promoting self-organized regional networks of data users, data brokers and providers, where closer linkages and collaborations are established with emphasis on an improved understanding of user requirements and product quality. GOFC/GOLD is pursuing, in a joint effort with the Committee on Earth Observing Satellites (CEOS) Land Product Validation (LPV) subgroup, the coordinated validation of fire products by standardized protocols. It is also partnering with the UN Interagency Task Force on Disaster Reduction (UNIATFDR) Working Group on Wildland Fire to improve access to data and information for informed policy making on fires. The presentation will provide an overview of the GOFC/GOLD-Fire goals, the various contributory projects, as well as the existing and emerging regional networks and validation activities in South-East Asia, Southern and Central Africa, Northern Eurasia and South America.

A31D-02 0920h INVITED

Long-term Forest Fire Monitoring and Mapping in North America from Satellite

Z. Li[1] (301-405-6699; zli@atmos.umd.edu); P. Gong[2]; R. Pu[2]; I. Csiszar[3]; W.-M. Hao[4]; R. Fraser[5]; A. Abuelgasim[5]

[1]ESSIC Dept. of Meteorology, University of Maryland, College Park, MD 20742

[2]Dept. of Env. Sci. Policy and Mgmt., University of California, Berkeley, CA CA94720-31

[3]Department of Geography, University of Maryland, College Park, MD 20742

[4]Fire Science Lab, USDA Forest Service, Missoula, MT

[5]Canada Centre for Remote Sensing, 588 Booth St., Ottawa, ON K1A 0Y7

Biomass burning in North America (NA) occurs primarily over forested regions. The fires are usually so intense that they not only destroy vast tracts of forest, but also release large quantities of chemical species (CO, CO2, methane, etc.) and particles (aerosol) to the atmosphere. The emissions can affect weather, climate, and environment across NA and even around the globe. For example, large fires in western Canada were found to influence air quality in the eastern seaboard of US and their emissions have been detected in the stratosphere over Asia. Fire activity and climate may have a strong interaction that remains to be unraveled. Given the significant impacts of fire, a major project is underway to systematically and accurately document all historical fires occurred in NA from 1985 till present as a part of the NASA's LCLUC program. This presentation will provide an update on the development, validation, and analysis of the fire product. Pros and cons of algorithms for monitoring and mapping fires, and for tracing fire smoke plumes will be assessed. The remote sensing fire products are compared with ground-based/air-borne fire observations. Variations and trends in fire activity are analyzed using multiple years of fire data.

A31D-03 0940h INVITED

An Overview of Recent Geostationary Fire Monitoring Activities and Applications in the Western Hemisphere

Elaine M. Prins[1] (608-263-6607; elaine.prins@ssec.wisc.edu)

Chris C. Schmidt[2] (608-262-7973; chris.schmidt@ssec.wisc.edu)

Joleen M. Feltz[2] (608-263-3434; joleen.feltz@ssec.wisc.edu)

[1]NOAA/NESDIS/ORA Advanced Satellite Products Team, UW-Madison Space Science and Engineering Center 1225 West Dayton St., Madison, WI 53706, United States

[2]UW-Madison CIMSS, 1225 West Dayton St., Madison, WI 53706, United States

Over the past twenty years the international scientific research and environmental monitoring communities have recognized the vital role environmental satellites can play in detecting and monitoring active fires both regionally and around the globe for hazards applications and to better understand the extent and impact of biomass burning on the global environment. Both groups have stressed the importance of utilizing operational satellites to produce routine fire products and to ensure long-term stable records of fire activity for applications such as land-use/land cover change analyses and global climate change research. The current NOAA GOES system provides the unique opportunity to detect fires throughout the Western Hemisphere every half-hour from a series of nearly identical satellites for a period of 15+ years. This presentation will provide an overview of the GOES biomass burning monitoring program at UW-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) with an emphasis on recent applications of the new GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA).

For the past 8 years, CIMSS has utilized the GOES-8 imager to monitor biomass burning trends in South America. Since September 2000, CIMSS has been producing half-hourly fire products in real-time for most of the Western Hemisphere. The WF_ABBA half-hourly fire product is providing new insights into diurnal, spatial, seasonal and interannual fire dynamics in North, Central, and South America. In North America these products are utilized to detect and monitor wildfires in northerly and remote locations. In South America the diurnal GOES fire product is being used as an indicator of land-use and land-cover change and carbon dynamics along the borders between Brazil, Peru, and Bolivia. The Navy is assimilating the Wildfire ABBA fire product into the Navy Aerosol Analysis and Prediction System (NAAPS) to analyze and predict aerosol loading and transport as part of the NASA-ESE Fire Locating And Mapping of Burning Emissions (FLAMBE) project. Furthermore, the dissemination and use of geostationary imagery and derived fire products in the Western Hemisphere provide a glimpse of future global geostationary fire monitoring capabilities. Global geostationary active fire monitoring will be possible with the launch of the European METEOSAT (METEOrological SATellite) Second Generation (MSG) and the replacement Japanese Multi-functional Transport Satellite (MTSAT-1R) over the next two years. This global network of geostationary satellites will complement the U.S. and international suite of environmental polar-orbiting satellites.

URL: http://cimss.ssec.wisc.edu/goes/burn/abba.html

A31D-04 1020h

Recent Developments for Satellite-Based Fire Monitoring in Canada

Abdelgadir Abuelgasim[1] (613-947-1231; aabuelga@ccrs.nrcan.gc.ca)

Robert Fraser[2] (613-947-6613; rfraser@ccrs.nrcan.gc.ca)

[1]Intermap Technologies, Canada Centre for Remote Sensing, 588 Booth Street, Ottawa, ON K1A 0Y7, Canada

[2]Canada Centre For Remote Sensing, 588 Booth Street, Ottawa, ON K1A 0Y7, Canada

Wildfires in Canadian forests are a major source of natural disturbance. These fires have a tremendous impact on the local environment, humans and wildlife, ecosystem function, weather, and climate. Approximately 9000 fires burn 3 million hectares per year in Canada (based on a 10-year average). While only 2 to 3 percent of these wildfires grow larger than 200 hectares in size, they account for almost 97 percent of the annual area burned. This provides an excellent opportunity to monitor active fires using a combination of low and high resolution sensors for the purpose of determining fire location and burned areas. Given the size of Canada, the use of remote sensing data is a cost-effective way to achieve a synoptic overview of large forest fire activity in near-real time.

In 1998 the Canada Centre for Remote Sensing (CCRS) and the Canadian Forest Service (CFS) developed a system for Fire Monitoring, Mapping and Modelling (Fire M3; http://fms.nofc.cfs.nrcan.gc.ca/FireM3/). Fire M3 automatically identifies, monitors, and maps large forest fires on a daily basis using NOAA AVHRR data. These data are processed daily using the GEOCOMP-N satellite image processing system. This presentation will describe recent developments to Fire M3, included the addition of a set of algorithms tailored for NOAA-16 (N-16) data. The two fire detection algorithms are developed for N-16 day and night-time daily data collection. The algorithms exploit both the multi-spectral and thermal information from the AVHRR daily images.

The set of N-16 day and night algorithms was used to generate daily active fire maps across North America for the 2001 fire season. Such a combined approach for fire detection leads to an improved detection rate, although day-time detection based on the new 1.6 um channel was much less effective (note given the low detection rate with day time imagery, I dont think we can make the statement about capturing the diurnal cycle). Selected validation sites in western Canada and the United States showed reasonable correspondence with the location of fires mapped by CFS and those mapped by the USDA Forest Service using conventional means.

A31D-05 1035h

Roadless Areas and Forest Fires in the Western United States

Jill Eastman[1] (301-314-2584; jceast@geog.umd.edu)

John Townshend[1,2] (301-405-4050; jtownshe@geog.umd.edu)

Christopher Justice[1] (301-405-3263; justice@hermes.geog.umd.edu)

Robert Sohlberg[1] (301-405-4292; rsohlber@geog.umd.edu)

[1]Department of Geography, University of Maryland, 2181 LeFrak Hall, College Park, MD 20742, United States

[2]Institute of Advanced Computing Studies, University of Maryland, A.V. Williams Building, College Park, MD 20742, United States

During the past two years, forest fires in the western United States have been analyzed and discussed in depth because of the severity of the fires and the associated damage to personal property. The number and extent of forest fires has been increasing, and many scientists believe that this increase will continue in the future. Forest management practices have been under close inspection because of their role in contributing to the current situation and the potential impact of management changes on fire mitigation and control. Industrialists and conservationists debate whether management (ie. road building, timber extraction, fire suppression) or conservation (ie. no new roads or logging) results in fewer fires that burn lesser extents. One example of a federal change in forest management practice is the Roadless Area Conservation Rule, enacted in 2001, which prohibited road construction in roadless National Forests. Opposition to the Rule is based in part on the assumption that roadless National Forests are more prone to forest fires, or conversely, managed forests are less prone to forest fires. Our analysis using data from the U.S. Forest Service Historic Fire Database and the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite instrument contradicts this view. We found that average annual fire frequency during the period 1986 to 2000 was 10% lower in roadless forests than in managed forests and that average annual burn extent was 31% lower in roadless forest. Thus, opening roadless forest to road construction in the western U.S. is sure to lead to an increase in number and extent of forest fires in the region.

A31D-06 1050h INVITED

Fire Research in the United States–The Challenge of Meeting Changing Management and Policy Needs

Susan G. Conard (703-606-5255; sconard@fs.fed.us)

Susan G. Conard, USDA Forest Service, Vegetation Management and Protection Research, RPC-4, P.O. Box 96090, Washington, DC 20090-6090, United States

Since the beginnings of government-sponsored fire research in the United States in the early 1900s, fire research has had close ties with fire management. However, as the social, economic, and environmental impacts of wildland fires and their management are increasingly recognized by the broader land management and environmental policy communities and by Congress, the roles, funding, and potential impacts of fire-related research are changing rapidly. Fire research is increasingly interdisciplinary and multiscalar. It is increasingly addressing a broader range of issues that require new competencies, new collaborations, new tools, and a strong vision of future needs. Fire is a dominant disturbance process in many terrestrial ecosystems, and its wise management is critical to society, to ecosystem health, and to resource sustainability. The challenges to fire research are great, the issues are complex. Developing research programs to meet these challenges is critical to ensuring protection of life and property, while meeting resource needs and maintaining a healthy environment.

A31D-07 1110h INVITED

FIRE BEAR Project: A Ground-based Validation and Remote Sensing Project for Forest Fire Assessment in Russia

Douglas J. McRae[1] (705-759-5740 (2180); DMcRae@NRCan.gc.ca); Susan G. Conard[2] (703-605-5255; sconard@fs.fed.us); Galina A. Ivanova[3] (7-3912-49-44-62; green@escape.akadem.ru); Anatoly I. Sukhinin[3] (boss@ksc.krasn.ru); Wei Min Hao[4] (406-329-4866; whao@fed.fs.us); Konstantin P. Koutzenogii[5] (7-3832-333753; koutzen@ns.kinetics.nsc.ru)

[1]Canadian Forest Service, Great Lakes Forestry Centre, 1219 Queen St. E., Sault Ste. Marie, ON P6A 2E5, Canada

[2]USDA Forest Service, P.O. Box 96090, Washington DC 20090-6090, United States

[3]RAS, V.N. Sukakachev Institute of Forest, Akademgorodok, Krasnoyarsk 660036, Russian Federation

[4]USDA Forest Service, Fire Science Laboratory, P.O. Box 8089, Missoula, MT 59807, United States

[5]RAS, Institute of Chemmical Kinetics and Combustion, Institutskaya St., 3, Novosibirsk 630090, Russian Federation

A forest fire research project, FIRE BEAR (Fire in the Boreal European Asia Region), is currently underway to quantify burn area, fire severity, emissions, and ecosystem fire effects in Central Siberia, Russia. These variables are important in assessing the contribution of boreal forest fires to the global carbon cycle. A series of replicated 4-ha experimental plots were burned during the dry season in 2000 and 2001. These experiments enabled us to characterize fire behavior (e.g., fire spread, fireline intensity), severity (e.g., fuel consumption) and smoke emission (e.g., gaseous, particulate and aerosol) in a dry Scotch pine forest using models based on ambient weather conditions at the time of burning. Our preliminary results show that between 3.2 and 10.6 t ha-1 of carbon is released from a surface fire under normal burning and weather conditions in a dry Scotch pine forest. Due to the lack of ladder fuels, no crown fires have been observed in our studies substantiating observations from fire managers and researchers that only a small percent of the area burned in the Scotch pine forest type is in crown fires. Combustion of small-diameter canopy fuels in a crown fire would only add an estimated 3.6 to 5.4 t ha-1 of carbon. In addition to our ground-based prescribed fire experiments, an aerial survey using infrared technology is being conducted to characterize selected wildfires. The results will be instrumental in validation of hot spots and burn scar algorithms used in many remote sensing projects that are currently being developed to understand the annual burn area in Russia and its contribution to carbon release.

A32A WCC: Hall D Wednesday 1330h

Wet and Dry Atmospheric Deposition and the Exchange of Chemically Reactive Trace Constituents Between Biosphere and Atmosphere I Posters

(joint with B, PA)

Presiding: **G Kramm,** University of Alaska, Fairbanks**; J Kesselmeier,** Max-Planck-Institute for Chemistry, Biogeochemistry Department

A32A-01 1330h POSTER

Effects of Chemical Reactions, Clouds, and Convective Precipitations on BVOC Emissions

Ralph Dlugi[1] (+49-89-30004258; rdlugi@gmx.de)

Michael Zelger[1] (+49-89-173711; michael@zelger-net.de)

Martina Berger[2] (+49-35203-31917; mberger@chip-club.de)

[1]AAP, Gernotstr. 11, Muenchen D-80804, Germany

[2]AAP, Grundbachtal 6, Tharandt D-01737, Germany

Measured fluxes of biogenic VOC (BVOC) fluxes from forested areas are analyzed with respect to the influences of clouds and chemical reactions. In a first step, clear sky data of fluxes of energy and chemical compounds are compared to the model FLAME for days with neglectable influences of advection and chemical reactions. Data from other experiments and model runs for these reference days show a hysteresis for energy and trace gas fluxes as function of surface radiation temperature T_S. Clouds modify this behaviour leading to unsteady jumps of fluxes to other points of the hysteresis or its interior. The observed duration of these phenomena is between $10^1 - 10^3$s, and therefore, overlaps with the different time scales, e.g. for statistical representative mean values, coherency of time series and their structures, chemical reactions and small scale advection. Convective precipitation causes a step change or shift of observed hysteresis. The influence of clouds, precipitation and chemical reactions could be satisfactory modelled by FLAME.

The data obtained for days with neglectable advection and low cloud cover are analyzed in a second step for the influences of chemical reactions on BVOC - fluxes. Reactions with $OH-$, NO_3 and even O_3 can lower the fluxes up to 280% depending on the dynamic and energetic conditions at the canopy - atmosphere interface. In a third step this model was applied to a region south of Berlin / Germany to show the combined influences of clouds, precipitation and chemical reactions on the net fluxes of BVOC from pine forests to the atmospheric boundary layer (ABL). The resulting input to the ABL significantly differs from currently applied emission algorithms.

URL: http://homepages.compuserve.de/atmosprocesses

A32A-02 1330h POSTER

Evaluation of Conditional Sampling Techniques for Measuring Vertical Fluxes of Chemically Reactive Trace Constituents

Gerhard Kramm[1] (907 474 5992; kramm@gi.alaska.edu)

Ralph Dlugi[2] (+49 89 3000 4258; rdlugi@gmx.de)

Peter Werle[3] (+49 8821 183-0)

[1]Giophysical Institute, University of Alaska Fairbanks, 903 Koyukuk Drive, Fairbanks, AK 99775-7320, United States

[2]Arbeitsgruppe Atmosphaerische Prozesse (AGAP), Gernotstrasse 11, Munich D-80804, Germany

[3]Fraunhofer-Institut fuer Atmosphaerische Umweltforschung, Kreuzeckbahnstrasse 19, Garmisch-Partenk. D-82467, Germany

The main differences between two different conditional sampling techniques, namely the eddy accumulation method (CS) and the relaxed eddy accumulation method (RCS), are to be described and their performance to "measure" vertical fluxes of chemically reactive trace constituents is to be evaluated. It will be shown that, in principle, the CS method is able to provide such vertical fluxes directly. Whereas the RCS method is based on a one-and-a-half-order-closure scheme that has to be verified for each individual trace species. Furthermore, the relative accuracy of the latter technique will be estimated on the basis of Bowen-ratio principles. Moreover, we shall argue that chemical traps are indispensable in conditional sampling techniques to avoid that chemically reactive trace species react with each other while accumulated.

A32A-03 1330h POSTER

Segregation Effects and their Impact on Chemical Transformation Rates and Vertical Fluxes of Atmospheric Trace Constituents

Gerhard Kramm[1] (907 474 5992; kramm@gi.alaska.edu)

Franz X. Meixner[2] (+49 6131 305 493)

[1]Geophysical Institute, University of Alaska Fairbanks, 903 Koyukuk Drive, Fairbanks, AK 99775-7320, United States

[2]Max-Planck-Institut fuer Chemie, Abteilung Biogeochemie, P.O. Box 3060, Mainz D-55020, Germany

Results of segregation effects determined during the SANA field experiment "Eisdorf" for the chemical reactions of ozone with NO and NO2 are to be presented and their impact on the corresponding reaction rates and the vertical fluxes of these trace species are to be pointed out.

A32A-04 1330h POSTER

A parameterization for modeling dry deposition of reactive trace species in complex terrain

Nicole Molders[1] (+1 907 474 7910; molders@gi.alaska.edu)

Detlef Hinneburg[2] (hinneburg@tropos.de)

Ralph Dlugi[3] (rdlugi@gmx.de)

Michael Zelger[3] (mzelger@gmx.de)

[1]Geophysical Institute University of Alaska Fairbanks, 903 Koyukuk Drive, Fairbanks, AK 99775, United States

[2]IFT, Permoser Str. 15, Leipzig D-04315, Germany

[3]AGAP, Gernot Str. 11, Munich D-80804, Germany

An explicit multi-layer subgrid-scheme to consider subgrid-scale surface heterogeneity, dry deposition of reactive trace species, biogenic and anthropogenic emissions of trace gases in chemistry transport models will be introduced and evaluated by heuristic principles. Special focus will be on the impact of the water cycle on dry deposition fluxes.

The results of simulations perfomed for different model resolutions with and without this scheme are evaluated by means of results from a simulation with 1km x 1km resolution, which is taken as a 'grand thruth' and which has the same resolution as the subgrid. The results gained with the explict multi-layer subgrid scheme well agree with the distributions of dry deposition fluxes that are obtained with the much more computationally expensive simulation with the 1x1 km2 resolution. Dry deposition fluxes determined from observations give evidence that the inclusion of the explicit multi-layer subgrid scheme leads to an improvement in modeling the exchange between the atmosphere and the ground.

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Atmospheric Deposition of Nitrogen and Sulfur in the Yellow Sea Region

Young Sung Ghim[1] (ysghim@kist.re.kr); J. Y. Kim[1] (jykim@kist.re.kr); S. B. Lee[1] (sblee2@kist.re.kr); K. C. Moon[1] (kcmoon@kist.re.kr); J. G. Won[2] (wonjg@air.snu.ac.kr); S. C. Yoon[2] (yoon@snu.ac.kr)

[1]Korea Institute of Science and Technology, 39-1, Hawolgok-dong, Seongbuk-gu, Seoul 136-791, Korea, Republic of

[2]Seoul National University, San 56-1, Sillim-dong, Gwanak-gu, Seoul 151-742, Korea, Republic of

The Yellow Sea is a semi-enclosed, shelf-type shallow basin with reduced water exchange with the open ocean. The rim of the Yellow Sea–the west side is China and the east side is Korea–is one of the fastest developing zones in the world. During the past several years, considerable measurements have been made both around and over the Yellow Sea in order to study the pollutant transport in the region. Fine particles as well as gaseous pollutants have been routinely measured at three national background monitoring stations on the Korean side. Two ground stations have been operated for supplementing these monitoring stations; one is on the Korean side and the other is on the Chinese side. Aircraft and shipboard measurements were also made during selected intensive measurement periods. However, not all these measurements have been made for a common object. Rather, several research teams carried out their measurements for their own purposes according to separate plans. In the present work, the amounts of nitrogen and sulfur deposited in the region of the Yellow Sea in both dry and wet forms were estimated. Concentration data available from each measurement were reviewed to choose adequate ones. Meteorological data at ground stations were readily obtained either from a collocated automatic weather station or from a surface weather station in the nearby area. However, those over the sea were estimated from the output of RDAPS (Regional Data Assimilation and Prediction System), which were provided by the Korea Meteorological Administration. Precipitation data were only available from several routinely operated ground stations since intensive measurements accompanying aircraft or shipboard measurements were not made on rainy days. The amounts of dry and wet depositions were compared at these stations. (This work was supported in part by the Korea Ministry of Science and Technology under grant 98-LO-01-01-A-003 and in part by the Sustainable Water Resources Research Center of the 21st Century Frontier Research Program.)