UPCOMING EAPS MEETINGS

EAPS STAFF MEETINGS
Thursday, Nov. 20th
9:00-10:00 a.m.
HAMP 2201

EAPS RECEPTIONS AT CONFERENCES

GSA (Vancouver)
Monday, Oct. 20, 2014
7:00 - 9:00 p.m.
Vancouver Hyatt Regency-Cypress Room

SEG (DENVER)
Monday, Oct. 27, 2014
6:00 - 8:00 p.m.
Denver Hilton Garden Inn-Element Ballroom

AGU (SAN FRANCISCO)
Wednesday, Dec. 17, 2014
7:00 - 9:00 p.m.
Thirsty Bear-Billar Room

AMS (PHOENIX)
Tuesday, Jan. 6, 2015
6:30 - 8:30 p.m.
TBA

FALL FACULTY MEETING SCHEDULE

Tuesday, Nov. 18th
3:00-4:30 p.m.
HAMP 3201

SPRING FACULTY MEETING SCHEDULE

Tuesday, Jan. 27th, Feb. 10th (Dean’s Visit to Dept.), Mar. 24th, and Apr. 14th, 2015
3:00-4:30 p.m.
HAMP 3201

EXTERNAL REVIEW
Nov. 3rd & 4th

Detailed schedule was placed in faculty mailboxes.

EAPS PRESENTATIONS

CLIMATE CHANGE IN THE 20TH CENTURY: LESSONS FROM THE DARK SIDE OF THE MOON
Dr. Richard A. Keen
Emeritus Instructor of Atmospheric Sciences, University of Colorado
Monday, Oct. 20, 2014 at 3:30 p.m.
Lilly 2-425

EAPS COLLOQUIA

TOWARDS A PARADIGM SHIFT IN THE MODELING OF SOIL ORGANIC CARBON DECOMPOSITION FOR EARTH SYSTEM MODELS
Yujie He
PhD Candidate
Tuesday, Oct. 21, 2014 at 4:00 p.m.
HAMP 2201

ANTHROPOGENIC SIGNALS IN INSAR
Rowena Lohman
Cornell University
Thursday, Oct. 23, 2014 at 3:30 p.m.
HAMP 1252

GIANT IMPACTS ON THE ASTEROID 4 VESTA
Timothy Bowling
PhD Candidate
Tues., Oct. 28, 2014 at 4:00 p.m.
HAMP 2201

(Please see attached fall 2014 EAPS Colloquia)

EAPS PUBLICATIONS

UNDERGRADUATE AND GRADUATE STUDENT INFORMATION

GREEN WEEK ACTIVITIES

A Discovery Lecture offered in conjunction with Purdue University’s Green Week 2014 will feature a talk by award-winning National Geographic magazine photographer Joel Sartore at 7 p.m. Monday (Oct. 20) in Purdue Memorial Union’s North Ballroom. The free lecture, titled "Photo Ark: Communicating Science through the Lens," will explore Sartore’s 20-year effort launched in 2008 to document endangered species and landscapes. More than 3,700 species have been photographed to date for Photo Ark.

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BILINGUAL CAREER FAIR AND RECEPTION

The CCO, in conjunction with the America China Society of Indiana, and Purdue Chinese Students and Scholars Association are hosting a Bilingual Career Fair and Networking Reception on November 3rd and 4th, 2014. Students with language and technical skills that are looking for both internships and full time opportunities should consider attending. Companies will be looking for students interested in both home country and international positions. All majors are welcome! Please see attached flyer.

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NETWORKING RECESSION

This event is a unique opportunity for students and employers to expand their professional networks and engage in meaningful discourse about international student success in the workplace.

Date: November 3, 2014
Time: 5:00-8:00 p.m.
Location: Dauch Alumni Center (403 W. Wood Street)

Keynote speech “Branchind you multiculturalism—present by Partrice Kimerson .

Students must register via my CCO. There is a limited capacity. Registration will close on October 28.

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BILINGUAL CAREER FAIR

Date: November 4, 2014
Time: 10:00am-3:00pm
Location: France A. Córdova Recreational Sports Center (Feature Gym)

View the list of attending employers.

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CCO WORKSHOPS

- LinkedIn - Online Networking
  Thu. Oct. 23 | 5:30-6:30pm | EE117
- Job and Salary Negotiation
  Wed. Oct. 29 | 5:30-6:30pm | EE117
- Acing the Interview
  Tues. Nov. 4 | 5:30-6:30pm | EE117

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GRADUATE STUDENTS-CHILD WELLNESS DAY

Tippecanoe County Health Department
October 24, 2014
10:00 a.m.-4:00 p.m.

To register online, please click here: https://www2.itap.purdue.edu/bs/worklife/
See attached flyer for more information.

NEW DEPARTMENTAL REGULATION

As you may be aware, the Graduate School has a new policy change with regards to plagiarism that began on September 1, 2014. All students (and their Major Professors) must sign a statement on Graduate School Form 32 certifying that their thesis/dissertation is free of plagiarism and all materials appearing have been properly quoted and attributed. Towards that end, your thesis/dissertation must now go through an iThenticate review. Therefore, the department has established a new departmental regulation with regards to this new policy. The new regulation states:

“A PDF of your final thesis/dissertation must be turned into the Graduate Committee or Major Professor a minimum of two weeks prior to thesis/dissertation deposit to conduct an iThenticate check. Failure to meet this deadline may affect submission of your thesis/dissertation which may, in turn, delay your graduation date.”

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2015 AMS TRAVEL GRANT FOR EAPS GRADUATE STUDENTS

A Travel Grant has been established by a donor to provide $500 in travel funds for an EAPS graduate student to attend and present at any American Meteorological Society (AMS) meeting. This call is for travel to AMS meetings that will be held in 2015. For a list of AMS meetings, see http://goo.gl/QeRYH2. The $500 travel award is limited to EAPS graduate students who plan to make an oral or poster presentation at any AMS meeting. Students may apply in advance of their paper/poster being accepted. Should a student be awarded the travel grant and their paper/poster is not accepted, the travel monies will be forfeited and will be made available to another student (at the discretion of the award selection committee). Students need to provide electronic files via email attachment to Kathy Kincade (kkincade@purdue.edu) including the cover sheet (2nd page of this document), an abstract and title of the proposed presentation, and an advisor’s letter of nomination by the
required due date to be considered. The awardee will be
selected by a faculty committee appointed by the Head. 
Awardees must submit a travel request a minimum of two
weeks before departure using the standard departmental 
travel procedures - see the Business Office for details. The 
unds will be provided as reimbursement for normal travel 
expenses.

The complete application must be submitted electronically to 
Kathy Kincade (kkincade@purdue.edu) by 5:00 PM on 
Thursday, October 30, 2014.

P. F. LOW AGU TRAVEL AWARD COMPETITION FOR 
EAPS PhD STUDENTS

The P. F. Low AGU Travel Award is sponsored by 
Professor Cushman to provide travel funds for one EAPS 
PhD student to make a presentation at the Fall (San 
Francisco, CA) American Geophysical Union (AGU) 
meeting. The award is named in honor of the late Philip F. 
Low, a member of the National Academy of Sciences and a 
pioneer in the rigorous use of thermodynamics for the study 
of clay-water interactions.

A travel award of (up to) $1000 will be awarded to support 
one EAPS student to present at the AGU fall meeting. 
Funds will be provided as reimbursement for normal travel 
expenses. Awards will be made based on merit of the 
research project, as well as on financial need. Students 
need to electronically provide the cover sheet (see below), 
an abstract of the proposed presentation, and an advisor’s 
letter of nomination by the required due date to be 
considered.

The complete application must be submitted electronically to Kathy Kincade (kkincade@purdue.edu) by 5:00PM on Thursday, October 30, 2014.

OTHER NEWS

AMERICAN METEOROLOGICAL SOCIETY CAREER FAIR 
95TH ANNUAL MEETING 
JANUARY 3-4, 2015

Participating in the AMS Career Fair is the perfect way for your organization to attract the attention of the thousands of professionals, recent graduates, and current students, expected to attend the AMS Annual Meeting in Phoenix, Arizona. The AMS Career Fair provides an environment to showcase full-time and part-time job opportunities, internships, graduate programs, and professional development opportunities. Whether you have jobs to fill or career advice to share, our attendees want to talk to you!

The Career Fair opens on Saturday, January 3 with a 
reception for the more than 700 graduate students and 
junior and senior undergraduate students expected to attend 
the 14th Annual AMS Student Conference. The Career Fair 
continues on Sunday, January 4 and is open to all Annual 
Meeting attendees, including attendees of the Early Career 
Professionals Conference. The hours of operation for 
Saturday and Sunday are as follows:

Saturday 5:30 p.m. – 7:30 p.m.
Sunday 5:00 p.m. – 7:00 p.m.

You’re invited to take advantage of this opportunity to promote your organization and to network with qualified applicants. If your organization is a Sustaining, Regular, or Small Business AMS Corporation and Institutional Member (CIM), your Career Fair registration is free of charge! Please contact Beth Farley at bfarley@ametsoc.org for a coupon code with which to submit your order. The registration fee for all other organizations, including Publication CIMs, is $120. All recruiters are provided with one 6’ table, two chairs, and access to Career Fair attendee resumes. To reserve space at the 2015 event, please visit our Web site at http://careercenter.ametsoc.org/home/index.cfm?site_id=42 and register as an EMPLOYER. Space is very limited so requests will be processed on a first-come, first-served basis. Specific information about the Career Fair will be emailed to you after we receive your reservation.

Visit the AMS Web site for additional information on the Career Fair and other Annual Meeting activities.

GLACIATION IN SWEDEN STUDY ABROAD COURSE 
MAY 4-JUNE 5, 2015

3 Credits: Estimated maximum cost $3,000, including tuition, all travel, food, and lodging (University and college study abroad scholarships may reduce this cost significantly)

Glaciation in Sweden focuses on reconstructing past glacial history based on an understanding of glacial processes combined with evidence from landforms and sediments. It involves course and fieldwork jointly with students taking an equivalent course at Stockholm University. This course is intended for juniors and seniors majoring in geology, as well as graduate students with interests in geomorphology and Quaternary geology. The study abroad course will run from May 4th to June 5th (May 4th-May 21st in West Lafayette, May 21st to June 5th in Sweden.

If you are interested, please send an email ASAP to the instructor at jharbor@purdue.edu letting him know you are interested. Expressing interest is not a commitment to take part in the program. This program will only be offered if there are enough students interested. If at least six people have expressed interest by October 25th, there will be an information session to discuss the details.

Please see attached flyer for more details.
IMPORTANT NOTICE ABOUT THIS NEWSLETTER
This newsletter is used as the primary information source for current and upcoming events, announcements, awards, grant opportunities, and other happenings in our department and around campus. Active links to additional information will be provided as needed. Individual email announcements will no longer be sent unless the content is time-sensitive. We will continue to include our publications, presentations and other recent news items as well. Those using paper copies of the newsletter should go to our newsletter archive on the EAPS website at www.purdue.edu/eas/ and Click on News to access active links as needed. Material for inclusion in the newsletter should be submitted to Fallon Seldomridge (fseldomridge@purdue.edu) by 5:00pm on Thursday of each week for inclusion in the Monday issue.

If it is in the newsletter, we assume you know about it and no other reminders are needed. For answers to common technology questions and the latest updates from the EAPS Technology Support staff, please visit http://www.purdue.edu/eas/info_tech/index.php.

Also, as an additional resource for information about departmental events, seminars, etc., see our departmental calendar at http://calendar.science.purdue.edu/eas/seminars.
Climate Change in the 20th Century:

Lessons from the Dark Side of the Moon

Dr. Richard A. Keen

Emeritus Instructor of Atmospheric Sciences, University of Colorado

The subject of climate change is huge and complex. This presentation will focus on two specific climate related topics, and extrapolate the results to the global climate change.

Volcanoes - The first is an examination of the impact of large volcanic eruptions on the transparency of the stratosphere, using observations of the brightness of lunar eclipses to determine the optical depth of volcanic aerosols. Between 1979 and 1995, aerosols from el Chichon (1982) and Pinatubo (1991) reduced the net heating (i.e., "radiative forcing") of the earth's surface. Since 1995, the absence of volcanic aerosols effectively increased the radiative forcing by 0.7 W/m², an amount slightly greater than the increased forcing due to all greenhouse gases (GHG). Using simple radiative calculations, the effects of volcanoes and GHG are sufficient to explain most of the 0.3C global temperature increase measured by the orbiting MSU sensors over the same time period. These observations imply a "climate sensitivity" to a doubling of CO₂ of 0.7°C, and that CO₂ induced global warming since 1900 is about 0.3°C.

Alaska - The other study is of the climate of central Alaska since the start of thermometer records during the 1899 Gold Rush. Alaska is noted for its volatile climate, with 30-year climatological means varying by 1°C to 2°C over the past century. Most (66 percent) of this variance is explained by the Pacific Decadal Oscillation (PDO) and/or North Pacific Oscillation (NP), which are internal oscillations of the earth-atmosphere system operating on time scales of ~60 years. External radiative forcings (solar, GHG, volcanoes) explain about 1 percent of the variance. The deconstructed contribution of CO₂ is 0.2°C, close to the result of the volcano study. Alaska is a relatively data rich region, but the sparse network of climate stations elsewhere around the planet may fail to catch similar large regional changes. Prior to 1979, the global coverage of climate stations is only about 30 percent, not sufficient for measuring global temperatures to an accuracy of 0.3°C.

Climate Change - Tying things together, a scenario that emerges is one of large ~1°C warm and cool regional changes due to ~60 year ocean-atmosphere oscillations superimposed on ~0.2°C global changes caused by radiative forcings over the same time scales. Although warm and cool regional changes may average out to contribute very little variation to the global mean, the irregular and sparse sampling of climate stations could lead to calculated global averages that are several tenths of a degree in error.
A Revised Tornado Definition and Changes in Tornado Taxonomy

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(Manuscript received 4 June 2014, in final form 30 July 2014)

ABSTRACT

The tornado taxonomy presented by Agee and Jones is revised to account for the new definition of a tornado provided by the American Meteorological Society (AMS) in October 2013, resulting in the elimination of shear-driven vortices from the taxonomy, such as gustnadoes and vortices in the eyewall of hurricanes. Other relevant research findings since the initial issuance of the taxonomy are also considered and incorporated, where appropriate, to help improve the classification system. Multiple misoscale shear-driven vortices in a single tornado event, when resulting from an inertial instability, are also viewed to not meet the definition of a tornado.

1. Introduction and considerations

The first proposed tornado taxonomy was presented by Agee and Jones (2009, hereafter AJ) consisting of three types and 15 species, ranging from the type I (potentially strong and violent) tornadoes produced by the classic supercell, to the more benign type III convective and shear-driven vortices such as landspouts and gustnadoes. This original taxonomy was presented to (i) help organize and sort out the variety of tornado occurrences, with different roles played by varying strengths and patterns of buoyancy/CAPE and shear/helicity, and (ii) to accommodate the change in nomenclature made by the American Meteorological Society (AMS) in the Glossary of Meteorology from its original 1959 definition to the revised definition in 2000 (Huschke 1959; Glickman 2000). These comments are being provided now because the AMS has revised the definition again in October 2013 (see http://glossary.ametsoc.org/wiki/Tornado), which has direct impact on the Agee–Jones taxonomy. The succession of three tornado definitions are (i) 1959—“a violently rotating column of air, pendant from a cumulonimbus cloud”; (ii) 2000—“a violently rotating column of air, in contact with the ground, either pendant from a cumuliform cloud or underneath a cumuliform cloud”; and (iii) 2013—“a rotating column of air, in contact with the surface, pendant from a cumuliform cloud, and often visible as a funnel cloud and/or circulating debris/dust at the ground.” In view of the latest definition, a few changes are warranted in the AJ taxonomy. Considering the roles played by buoyancy and shear on a variety of spatial and temporal scales (from miso to meso to synoptic), coupled with the requirement in the latest definition that a tornado must be pendant from a cumuliform cloud, it is necessary to reexamine the AJ taxonomy.

a. Changes in the taxonomy

There are some minor and/or significant changes in each of the three types of tornado classification due to a combination of the following: the new tornado definition, recent research investigations, comments by Markowski and Dotzek (2010, hereafter MD), and e-mails received by the author. Purely shear-driven vortices (although indirectly associated with cumuliform clouds) must be dropped from the original AJ taxonomy. This includes the gustnadoes (type IIId), as well as hurricane eyewall shear vortices (type IIIe).

Contrary to the wishes of many in the severe storms community, the 2000 Glossary defined gustnadoes as tornadoes (which AJ had no choice in the matter in presenting their taxonomy because of their adherence to the Glossary definition). Considering now in the new definition that the vortex in contact with the ground “must be pendant from a cumuliform cloud” implicates the presence and role of convective buoyancy in vortex formation (thus eliminating shear vortices as noted...
Tornado Classification System

**Type I**
- Supercells (with Mesocyclone)
  - Ia- Classic Supercells (SR, SL)
  - Ib- Low-Top Mini-Supercells
  - Ic- Tropical Storm/ Hurricane Related Mini-Supercells
  - Id- Anticyclonic Secondary Vortices

**Type II**
- QLCS (Cold Pool, Shear, Mesocyclone)
  - Ila- LEWPs
  - Ilb- Bows
  - Ilc- BEVs
  - Ilc- Other Mesovortices

**Type III**
- Localized Convective and Shear Vortices
  - Ila- Landspouts
  - Ilb- Waterspouts *
  - Ilc- Cold Air Funnels

*Type I and Type II "waterspouts" are also possible

FIG. 1. Revised tornado taxonomy (after Agee and Jones 2009).

above) but continuing to allow tornadoes in the type III class, namely landspouts, waterspouts (with landfall), and even a few cold-air funnels when in contact with the ground. Simply stated, the combined roles of shear and buoyancy, as well as the associated dynamical and kinematic processes of tilting–convergence–stretching, must act together in the presence of a cumuliform cloud updraft embedded in a wind shear environment to form a vortex that is a candidate for becoming a tornado. It is further noted that the anticyclonic secondary vortex (type IIIIf) has been relocated in the revised taxonomy to type I (and labeled as Id). This relocation is consistent with the recommendation made by MD, as well as by Agee and Jones (2010, hereafter AJ2). Changes in type II species are minor, but the nomenclature of rear inflow jets (RIJs) has been changed to inflow jets (IJs) since inflow features that occur in quasi-linear convective system (QLCS) events can be either from the front or the rear. Accordingly, an updated taxonomy is presented in Fig. 1, as well as a newly revised table of taxonomy species criteria (Table 1). The comment and reply articles by MD and AJ2, as well as the reviews received for this publication, require additional comments regarding tornadic supercell thunderstorms. Admittedly, there are some mixed views concerning the placement (or not) of supercells in lines (i.e., in the type II classification). Although QLCS may contain storm cells with some characteristics of the supercells, they do not meet the definition of discrete entities as defined in the type I classification. Tornadic supercells can be in a line but separated (and not in a solid QLCS) and thus consistent with the classification criteria.

b. Multiple vortices and tornado definition

The occurrence of multiple vortex tornadoes has long been recognized, as seen in the early observations of the 3 April 1974 tornado outbreak (Agee et al. 1975). A single tornadic thunderstorm is also capable of supporting two or more minitornado cyclones (Agee et al. 1976) capable of producing individual tornadoes, resulting in a parallel mode tornado family [also see Fujita (1974)]. Over the decades there have been many observations and investigations of vortices associated with tornado events, but nothing comparable to those reported on by Wurman and Kosiba (2013, hereafter WK). The complexity of their Doppler observations of a multitude of vortices on several different scales has resulted in their proposal for a new tornado definition and, thus, requires some consideration in this contribution. The author views that tornadoes (particularly strong and violent tornadoes) can (and should) display multiple vortex features with a variety of sizes. Large two-cell vortices (such as wedge tornados) can be viewed as a coalescence or bundling of vortex tubes of different sizes. Such are sometimes visible to even the naked eye and at an impressive level, as is evident in the movies of the Tuscaloosa, Alabama, tornado of 27 April 2011. However, the unprecedented findings by WK bring into focus the complexity of tornado formation and structure, with its plethora of vortices. Many, if not most, of these cases are shear-driven vortices that are also capable of coalescing into a spectrum of vortex sizes. In spite of this complexity and the importance of their findings, the author does not
see a basis for changing the taxonomy presented or the AMS definition of a tornado.

2. Summary and conclusions

In summary, the author is pleased with the latest AMS definition of a tornado and equally pleased to eliminate two tornado species from the original AJ taxonomy. Also, this revision has provided an opportunity to make additional minor changes in the taxonomy (as suggested by others in the research community). Further, a brief discussion of the potential impact of the WK Doppler investigation of tornado-associated vortices on the AMS definition has been provided. Equally important is consideration of the study by Smith et al. (2012), which defines convective modes for significant severe thunderstorms and tornadoes, based on 78.5% of all such CONUS reports from 2003 to 2011. Their three categories were QLCS, supercells, and disorganized, along with a number of subcategories such as bow echo, discrete cell, cell in cluster, cell in a line, marginal supercell, and linear hybrid. Clearly, these convective categories bear a strong similarity to the tornado taxonomy classifications (and should), but they are not the same.

Although it has taken several decades, the newest tornado definition seems solid and is not likely to change again. It is not viewed as being compromised by new discoveries such as those by WK (although change is always possible when warranted).

REFERENCES

Adjustments in Tornado Counts, F-Scale Intensity, and Path Width for Assessing Significant Tornado Destruction

ERNEST AGEE AND SAMUEL CHILDS
Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, Indiana

(Manuscript received 12 July 2013, in final form 30 January 2014)

ABSTRACT

The U.S. tornado record is subject to inhomogeneities that are due to inconsistent practices in counting tornadoes, assessing their damage, and measuring pathlength and path width. Efforts to improve the modern tornado record (1950–2012) have focused on the following: 1) the rationale for removing the years 1950–52, 2) identification of inconsistencies in F0, F1, and F2 counts based on implementation of the Fujita scale (F scale) and Doppler radar, 3) overestimation of backward-extrapolated F-scale intensity, and 4) a change in path-width reporting from mean width (1953–94) to maximum width (1995–2012). Unique adjustments to these inconsistencies are made by analyzing trends in tornado counts, comparing with previous studies, and making an upward adjustment of tornadoes classified by mean width to coincide with those classified by maximum width. Such refinements offer a more homogeneous tornado record and provide the opportunity to better evaluate climatological trends in significant (F/EF2–F/EF5) tornado activity. The median EF-scale (enhanced Fujita scale) wind speeds $V_{med}$ have been adopted for all significant tornadoes from 1953 to 2012, including an adjustment for overestimated intensities from 1953 to 1973. These values are used to calculate annual mean kinetic energy, which shows no apparent trend. The annual mean maximum path width $PW_{max}$ from 1953 to 2012 (adjusted upward from 1953 to 1994 to obtain a common lower threshold), however, displays an increasing trend. Also, the EF-scale median wind speeds are highly correlated with $PW_{max}$. The quantity $(V_{med} \times PW_{max})^2$ is proposed as a tornado destruction index, and, when calculated as an annual cumulative value, the three largest years are 2007, 2008, and 2011.

1. Introduction

Analyses of tornado intensities, their trends, and patterns of destruction through time are of great importance in the realm of climate science and to society in general. Scientists can be limited, however, by a lack of cohesive statistics in the modern tornado dataset (1950–2012). Considerable attention has been given to U.S. tornado statistics to determine the distribution function for their intensity, as well as the potential relationship of their intensity to pathlength and path width (Dotzek et al. 2003, 2005; Brooks 2004). The creation of the Fujita (F) and enhanced Fujita (EF) scales has introduced potential impacts on the interpretation of the U.S. tornado record. For example, both scales attempt to use tornado damage to quantify maximum wind speeds, but limitations exist in damage-assessment subjectivity and application, as well as in available targets and objects that can be damaged, as discussed by Doswell et al. (2009), Edwards and Brooks (2010), and Edwards et al. (2013). It is well known that maximum wind speed and the types of structures in the path, along with airborne debris and missiles, play a major role in causing tornado damage and as such are related to the ultimate assignment of F/EF-scale values. Thus, not only velocity $v$, but also $v^2$ and $v^3$, are important considerations in evaluating damage potential (Emanuel 2005). This study specifically chooses to use $v^2$, since dynamic-pressure wind loading onto barriers is directly proportional to the free-stream kinetic energy. There have been efforts to improve or establish more internationally recognized wind speed scales (Dotzek 2009), but there remain opportunities to adjust for discrepancies and to create a more homogeneous record of U.S. tornado events [for 1950–2012, as archived in Storm Data (described below), which is also accessible online from the Storm Prediction Center (http://www.spc.noaa.gov/wcm/)]. This study attempts to adjust for these discrepancies—to be specific, for significant tornadoes [$\geq F/EF2$; originally defined by Hales (1988)].
The proposed adjustments are based on the following: 1) establishing the best year for beginning the tornado record, 2) illustrating the heterogeneities in the F0 count for different periods of time, 3) identifying the undercounting of F1 events and the overcounting of F2 events that took place prior to 1974 and revising to establish a more homogeneous record, 4) making adjustments to inflated F-scale values (and thus speed estimates) from prior to 1974, and 5) establishing a more complete tornado record for maximum path width, recognizing that mean tornado path width was recorded in the years prior to 1995.

Upon finding and implementing adjustments to the above, the opportunity exists to reexamine tornado intensity trends through time, particularly in significant tornado counts, their kinetic energy, and maximum path width (as well as the possible relationship of the median EF-scale wind speed value with maximum path width). Further, to provide a way to better assess the magnitude of tornado damage on the basis of F/EF-scale wind speed estimates, this study introduces a tornado destruction index (TDI). It is noted that this index does not explicitly consider the geography of population distribution and construction practices along the path of individual tornadoes. Analysis of the annual cumulative values of the TDI parameter (TDIC) is also made to look for evidence of climatological trends and/or idiosyncrasies in archiving method.

2. Data accountability, adjustments, and analysis

The Storm Prediction Center maintains a modern tornado data record, compiled from the Storm Data archive at the National Climatic Data Center (NCDC), and currently includes tornado attributes for the period of 1950–2012. Numerous efforts have been made to provide the most accurate data [the most recent being the introduction of the EF scale; see assessment by Edwards et al. (2013)], but there remain succinct biases in a number of the attributes, some of which have been addressed (Schaefer and Edwards 1999; McCarthy 2003; Doswell 2007). Specifically applicable to this study are biases that exist in both reported count and damage magnitude of tornadoes throughout the period that inhibit accuracy of analysis and/or require the omission of large portions of the data record to avoid such biases. Differences in path-width reporting (from mean to maximum) are also addressed.

a. Homogeneous versus heterogeneous records

One of the concerns to be examined is associated with the first three years of the modern tornado data record: 1950–52. Efforts to extend the tornado record back in time to before the establishment of the National Severe Storms Forecast Center in 1953 have been pursued with support from the U.S. Nuclear Regulatory Commission (Tecson et al. 1979) and independently by Grazulis (1993). These efforts involved searching newspaper reports and old photographs—useful but limited resources that may not allow for accurate tornado attributes (Doswell and Burgess 1988; Schaefer and Edwards 1999). Figure 1 shows the annual tornado count through time, which has been increasing since 1950 as a result of a variety of factors (population growth, increasing numbers of storm chasers and observers, verification methods,
technological advancements, etc.). It is evident from this and subsequent figures that the 1950–52 data record may have credibility issues (based in part on the assessment method and the long period of elapsed time in compiling data). The decision to eliminate these three years of data from the study is discussed below, along with subsequent analyses that support such action.

Another source of heterogeneity comes from improved tornado counting (especially for weaker tornadoes) with the implementation of the Weather Surveillance Radar-1988 Doppler (WSR-88D) network, which occurred during the early 1990s and was completed in 1997 (Crum et al. 1998). Doppler radar allows for the possibility of detecting a vortex circulation that coincides with local wind damage of F/EF0 strength. Agee and Hendricks (2011) have shown evidence of a similar technological effect in the climatological data of hurricane-induced tornadoes. Figure 2 shows the count of F/EF0 tornadoes for 1950–2012 and an apparent discontinuity in the data in the early 1990s (supported by the \(t\)-test comparison of means, significant at the 0.01 confidence level), coinciding with the implementation of the Doppler radar network. This technological advancement has allowed meteorologists to better detect mesocyclones that may produce weak tornadoes and consequently to record more events than during the pre-Doppler era. Although Verbout et al. (2006) note that nearly all of the increase in tornado reports during the past 50 years can be attributed to increased reporting of F/EF0 tornadoes that is largely due to population increase, it is noted that the magnitude of the increase in the early 1990s (Fig. 2) cannot be explained by population growth. It is also interesting to note that there is an increase in both counts and variability in the F/EF0 record after the implementation of Doppler radar, as depicted by the “fanning” pattern of data.

A third area of concern, and most applicable to the current study, is that of the overcounting and overrating the intensity of F2 versus F1 tornadoes, specifically before the implementation of the F scale in 1974, as noted by Grazulis (1993). Figure 3a shows the F/EF1 tornado counts from raw data files and illustrates the general undercounting of F1 tornadoes prior to 1974, as well as a cluster of low values for 1950–52. The F/EF1 tornado counts from 1974 to 2012 show a more homogeneous, stationary pattern (with an average of 336 tornadoes per year), accompanied by random variability (correlation coefficient squared \(r^2 = 0.0144\)). Contrary to the F/EF0 record, no spike in reporting is seen during the time of Doppler radar implementation. Further, as seen in Fig. 3b, the F2 count prior to 1974 is noticeably elevated, except for the cluster of the three years 1950–52. Coupling the observations of too few F1s and too many F2s for the period of 1953–73, when compared with the subsequent years, allows the authors to draw a reasonable conclusion that there was an assignment of excessively high values of wind speed range for many of the F2 events. When all
data are combined (see Fig. 3c for F/EF1–F/EF5), the record appears to be mostly homogeneous and stationary [as reported by Verbout et al. (2006)]. This conclusion does not follow, however, since the potentially overestimated F2 and underestimated F1 counts have been added together, masking the real signal.

As noted, the cluster of the three years 1950–52 appears to be outside the distributions for particular tornado counts in each of Figs. 1, 2, and 3a–c, and it follows that the authors have elected to begin their study with 1953. Note that Verbout et al. (2006) start their analysis with 1954, which is also reasonable.

A fourth area of concern is the shift in the data record for reporting tornado path width. Although there was some gradual overlap of both mean and maximum path-width reporting, it was not until 1995 that the change was completed, as noted by Brooks (2004). A method is introduced below for building a maximum path width record from 1953 to 2012.

b. **Refinements and method**

   **1) COUNTS**

   Significant tornadoes (F/EF2–F/EF5) produce the greatest destruction. In accord with this situation, it is assumed that the contemporary significant tornado statistics (1974–2012) are more reliable than those from the earlier period, because of increased knowledge, as well as more complete field investigation and documentation.

   Figure 4 is presented to show comparisons between pre-F-scale and post-F-scale counts for equal time periods (1953–73 and 1974–94, respectively), and it is reasonable.
to consider making adjustments to the data. The specific focus is on F2 events, which account for 85% of the total significant tornado difference (between the two adjoining 21-yr periods), as previously explained in Fig. 3b. The method for adjustment (Table 1) begins with calculating the mean counts of F1 and F2 tornadoes for the two periods, which establishes an F1:F2 ratio for each period. To remove the overcounting of F2s in the early period, their count is lowered (and the F1 count consequently raised) until the ratios are equal. New mean counts for F1 and F2 tornadoes are found following the adjustment, and the percent change in F1 mean counts is found to be 27.6%:

\[
\text{Count correction factor} = \frac{\mu_2 - \mu_1}{\mu_1} = \frac{310 - 243}{243} = 0.2757 \rightarrow 27.6%.
\]

This is the factor by which F2 counts are lowered (and F1 counts raised) in the 1953–73 period. There was not sufficient rationale to make comparable types of adjustments to the small differences in F3–F5 tornado counts, because of the infrequency of their occurrence (Verbout et al. 2006). The annual plot of adjusted significant tornado counts is presented in Fig. 5. With the adjustment, the mean count of significant tornadoes for the pre-F-scale era (1953–73) is lowered from 243 to 191, which is closer to the mean count of 158 for the post-F-scale era (1974–2012). Still, a weak decreasing trend in significant tornado counts exists, which is consistent with previous research (Doswell et al. 2009). Fewer significant tornadoes does not necessarily imply a decrease in destruction from tornadoes, however (a topic discussed in a later section).

2) INTENSITY AND WIND SPEED

Since actual maximum wind speeds of tornadoes are estimated, the approach used in this study is to adopt the median wind speed value \( V_{\text{med}} \) (from the EF scale) for each of the respective EF ratings of all significant tornadoes (except for the EF5 rating, where the minimum estimated wind speed is used because of the infrequency of events). These median wind speeds are equivalent to the mean of the estimated wind speeds of the upper and lower bounds for that particular EF rating [e.g., for EF2 rating, \( V_{\text{med}} = (111 \text{ mi h}^{-1} + 135 \text{ mi h}^{-1})/2 \), converted to meters per second]. The EF scale, being a more recent way to estimate tornado intensity than the F scale [see assessment by Edwards et al. (2013)], is used throughout this study for assessing median wind speeds and calculating kinetic energy. Further, Widen et al. (2013) have noted that the F scale and the EF scale can be considered to be equivalent for climatological studies. Not only have

<table>
<thead>
<tr>
<th>Intensity</th>
<th>F1 mean count</th>
<th>F2 mean count</th>
<th>F1:F2 ratio</th>
<th>Corrected mean count: F1</th>
<th>Corrected mean count: F2</th>
<th>Corrected F1:F2 ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>243</td>
<td>187</td>
<td>1.3</td>
<td>310</td>
<td>120</td>
<td>2.6</td>
</tr>
<tr>
<td>F2</td>
<td>332</td>
<td>128</td>
<td>2.6</td>
<td>332</td>
<td>128</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Fig. 4. Average annual significant tornado counts for the periods 1953–73 (pre–F scale) and 1974–94 (post–F scale).
the F2 counts been revised, but also the representative median wind speeds have been adjusted (per the EF scale) because all counts are viewed as having overestimated wind speeds (even the fraction that is retained in the F2 category). The magnitude of the wind speed adjustment is determined by the change in percent of the total F1 and F2 counts that is attributed to F2 tornadoes following the count adjustment (see Table 1):

Wind speed correction factor

\[
= 100 \left( \frac{n_{F2}}{n_{F1} + n_{F2}} \right)_{\text{before}} - 100 \left( \frac{n_{F2}}{n_{F1} + n_{F2}} \right)_{\text{after}}
\]

\[
= 15.6 \rightarrow 15.6\% ,
\]

where \( n_{F1} \) and \( n_{F2} \) are the number of F1 and F2 counts, respectively. Thus, the principle now invoked (viz., correction of overestimation of F2 counts as a result of a perception of higher maximum wind speeds than what actually occurred) results in a 15.6% reduction in the median wind speed for the EF2 rating. It is reasonable to note for consistency that all significant tornado scales should receive a similar adjustment for the 1953–73 period (Table 2). Figure 5 shows that this approach and adjustment yield more homogeneous records and stationary patterns than are seen in the raw data. This adjustment may not create the perfect set of wind speed data, but it is an improvement.

3) PATH WIDTH

The U.S. tornado database provides the mean path width of tornado events from 1950 to 1994 but provides maximum path width from 1995 to the present. Figure 6 shows the annual mean values of significant tornado path widths for the two periods (1953–94 and 1995–2012), which reveals a discontinuity jump in their respective lower thresholds of approximately 209 m (supported by a \( t \) test comparing different population means, significant at the 0.01 confidence level). In an attempt to equate these two different populations, mean width values have been increased by 209 m and are renamed “maximum” width values. The entire record (1953–2012) is now represented by a single lower threshold (as shown in Fig. 7), and the mean values of maximum path width for each of the four significant EF-scale ratings have been matched by making an upward adjustment of 52 m (209/4) for the period of 1953–94. The trend of path widths through time shows increasing variability with a recent uptick toward wider tornadoes; improved methods of measuring path widths may be responsible for some of the variability, however.

Table 2. Intensity corrections made to the EF-scale intensity ratings for 1953–73.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Velocity range (mi h(^{-1}))</th>
<th>( V_{\text{med}} ) (mi h(^{-1}))</th>
<th>( V_{\text{med}} ) (m s(^{-1}))</th>
<th>( V_{\text{adj}} ) (m s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF2</td>
<td>111–135</td>
<td>123</td>
<td>55.0</td>
<td>46.4</td>
</tr>
<tr>
<td>EF3</td>
<td>136–165</td>
<td>150.5</td>
<td>67.3</td>
<td>56.8</td>
</tr>
<tr>
<td>EF4</td>
<td>166–200</td>
<td>183</td>
<td>81.8</td>
<td>69.0</td>
</tr>
<tr>
<td>EF5</td>
<td>&gt;200</td>
<td>200*</td>
<td>89.4*</td>
<td>75.5*</td>
</tr>
</tbody>
</table>

* Minimum speed is used for EF5 intensity because of the difficulty in assigning a median value.
4) MAXIMUM PATH WIDTH AND TORNADO INTENSITY

From previous results, it is now possible to examine the relationship of the adjusted maximum path width to the median value of EF-scale wind speeds (Fig. 8). The linear distribution of these data points shows an approximately 170-m increase in maximum tornado path width for each 10 m s\(^{-1}\) increase in \(V_{\text{med}}\) (with an \(r\) value of 0.981), which is a plausible result since one might expect wider tornadoes to have higher ratings because of the increased opportunity to impact more buildings of greater structural integrity. Minimal uncertainty in this relationship exists, as expressed by the error bars in Fig. 8, except for EF5, which is characterized by a small number of events. Also, many tornadoes are not steady-state systems, multiple vortices can be present, and the aerodynamics of surface boundary layer vortex spinup can differ, all of which represent opportunities to produce variation in maximum path width versus intensity rating. It is noteworthy, however, that although this result is derived from a different method it is consistent with the
Weibull distribution parameters for the F scale in general, as reported by Brooks (2004).

3. Kinetic energy and tornado destruction

Although kinetic energy and related quantities for tornadoes have been considered in past studies (e.g., Dotzek et al. 2005; Dotzek 2009), the adjustments to the U.S. tornado record presented in this study now allow for reinvestigation of such quantities. To be specific, the focus is on kinetic energy for significant tornadoes for the period of 1953–2012, as well as the introduction of a new quantity for examining the TDI.

a. Kinetic energy

As discussed in the introduction, this study has chosen \( y^2 \) for addressing tornado damage, because of its relationship to dynamic pressure buildup on obstacles to the flow. Further, Dotzek et al. (2005) noted that tornado intensities are exponentially distributed over the peak wind speed squared \( (v^2) \), particularly for significant tornadoes. Even if this study had chosen the advective transport of kinetic energy \( (v^3) \), used in calculating power dissipation, the results would provide the same conclusion.

The method for calculating the annual total kinetic energy for the period of 1953–73 is presented in Table 3, which incorporates the noted adjustments (reduction in F2 counts and 15.6% reduction in \( V_{med} \)). In a similar way, Table 4 shows calculations for the unadjusted period of 1974–2012. The range of wind speeds for the respective EF-scale rating has been used for all years in establishing median values \( V_{med} \), and the square of these values gives the kinetic energy per intensity rating. Multiplying this value by the respective number of events per intensity rating and then summing the four (EF2–EF5) totals gives a total kinetic energy for each period. A mean kinetic energy per significant tornado per year can then be computed, as shown in Tables 3 and 4.

![Fig. 8. Median EF-scale wind speeds \( V_{med} \) vs adjusted mean maximum path width \( (PW_{max}) \) for 1953–2012, with error bars at the 95% confidence level.](image)
approach, Fig. 9 shows the adjusted total significant tornado kinetic energy per year for the entire record, which is stationary (see linear-fit dashed line). This is further supported by the mean kinetic energy per significant tornado per year being very similar (1.23 \times 10^5 \text{ m}^2 \text{s}^{-2} for 1953–73 vs 1.40 \times 10^5 \text{ m}^2 \text{s}^{-2} for 1974–2012), as shown respectively in Tables 3 and 4. Two years, 1974 and 2011, are noted outliers, with all other departures randomly distributed from the fitted line ($r^2 = 0.0026$), as characteristic of a stationary time series.

b. Tornado destruction index

Kinetic energy trends give a sense of how the strength of tornadoes is changing through time, but they fail to account for the trend in tornado widths, which reveals how much area is being influenced and possibly damaged at a given point in time. As noted by Thompson and Vescio (1998), the potential for tornado damage should be related to tornado intensity, path width, and path-length. In fact, they introduced a destruction potential index (DPI) for measuring potential damage associated with a single tornado outbreak. Their index multiplies the tornado intensity rating and the total area of each given track, all of which are summed for a single outbreak and compared (e.g., Palm Sunday 1965 vs 3 April 1974). The parameter for estimating the intensity of tornado destruction presented in the current study is different than DPI and has an objective that considers all significant tornadoes on an annual basis for the entire tornado record. TDI is directly proportional to the pressure exerted by wind loading on barriers to the flow [which is proportional to ($V_{\text{med}}$)$^2$ for the given EF-scale intensity] as well as the maximum path width ($PW_{\text{max}}$)$^2$ that defines a unit of area containing such obstacles:

$$TDI = (V_{\text{med}} \times PW_{\text{max}})^2.$$ (1)

As shown in Fig. 8, the magnitude of tornado destruction at the time of maximum intensity increases as EF rating increases. Given that the tornado has its maximum velocity rating $V_{\text{med}}$ as it advances across the area $PW_{\text{max}}^2$, it is appropriate to assume that every point in this unit area is exposed to maximum local damage. It is noted that the outer boundaries of the maximum width area obviously do not receive the maximum wind speed, but this physical property of the vortex is characteristic of all events (and the individual TDI calculations are systematically made for all events). Further, this “collateral” damage should be related to tornado intensity and path width. Therefore, a cumulative parameter for significant tornadoes can now be defined as $TDI_C$, the cumulative tornado destruction index:

$$TDI_C = \sum_{n=2}^{5} (N_n V_{\text{med}_n}^2 \times (PW_{\text{max}_n})^2,$$ (2)

where $N_n$ is the number of events per rating, $V_{\text{med}_n}$ is the median EF-scale wind speed, $PW_{\text{max}_n}$ is the mean maximum path width per rating, and $n$ is the EF-scale intensity.

The annual totals of $TDI_C$ are presented in Fig. 10, which suggests a quasi-stationary pattern through 2006, with 1965 holding the record for highest $TDI_C$. It is noteworthy, however, that three of the last six years (2007,
2008, and 2011) have produced record values of TDI\textsubscript{C}, which is due in part to greater values of PW\textsubscript{max}. The results in Fig. 10 show a possible trend in TDI\textsubscript{C} and the increasing variability in total annual tornado destruction. Note that the ratio of significant tornadoes to total tornadoes has gone from 7.2% in 2004 to 13.2% in 2012, despite the decrease in significant tornadoes (see Fig. 5). The maximum path width may be contributing to this upturn in TDI\textsubscript{C}, however (see Fig. 10). Also worthy of consideration is the possible movement of intensity ratings toward the middle categories (EF2 and EF3) with the introduction of the EF scale (Edwards and Brooks 2010). Continual monitoring of TDI\textsubscript{C} provides an opportunity to detect changes in tornado destruction on a climatological time scale.

4. Summary and conclusions

Although several improvements to the modern U.S. tornado record (1950–2012) have been offered in past and current work, issues with the tornado archive remain that may be difficult to address. Doswell et al. (2009) discuss a systematic underrating of tornadoes in the most recent decade that is due to policy changes at the National Weather Service, and it is further noted that concerns related to the EF scale have been raised by Edwards and Brooks (2010). Verification policies that were implemented during NWS modernization and the Doppler upgrade may also influence interpretation of the tornado data. Also, attention needs to be given to societal influences on tornado statistics and the nature of damage accounts for individual events. Factors such as population density, structural integrity of buildings and homes, human response, and geographic differences in a multitude of factors can potentially affect the tornado record [see Ashley (2007) and numerous references within that publication]. In addition, Brotzge and Donner (2013) cite several societal and cultural challenges in how the public is made aware of and heeds a tornado warning. These include personalized risk, knowledge from past experience, income differences, and feasibility of taking action to protect life and property.

The study presented here offers unique adjustments to improve the analysis and interpretation of tornado data and associated statistical inferences. To be specific, the years 1950–52 are shown to be inappropriate for inclusion in the data analyses presented. Identification of inconsistencies in F0, F1, and F2 counts are found to coincide with the beginning of the F-scale method, as well as the implementation of Doppler radar. The F0 counts prior to Doppler are noticeably low, but with Doppler the counts are much higher with greater variability. It is conjectured that higher F0 counts are largely due to the capability of detecting radar vortex structures for areas of relatively weak tornado damage (that otherwise might not have been labeled as tornadic). Next, the F1 counts are too low, prior to the introduction of the F-scale method, and the F2 counts are too high for the same period. Refinements have been presented that move 27.6% of the inflated F2 counts down to the F1 category. Although previous work (e.g., Verbout et al. 2006) states that the F1–F5 annual tornado counts are stationary, the current work shows how this record can be viewed as stationary once the adjustments to F1 and
F2 counts are made [consistent with the findings by Grazulis (1993)].

Because of the obvious importance of significant tornadoes in producing death and destruction, considerable attention has been given to these data trends for 1953–2012. Even with the adjustments to the F2 counts before 1974, the significant tornado annual totals are trending down [as noted by Doswell et al. (2009)], raising the question of the possible cause for such a trend. The size of these destructive tornado events has also been brought into consideration, however. From 1953 to 1994, the mean tornado path width was recorded, but from 1995 to present it has been replaced with the maximum path width. Lower thresholds for each time period have been identified, and an adjustment of 209 m has been added to the annual mean path width for 1953–94 (thereby providing a longer and more homogeneous record of maximum tornado path width). This lower threshold adjustment also resulted in each of the four significant EF-scale ratings having an addition of 52 m (i.e., 209/4) to their mean maximum path widths. Although significant tornadoes are trending down, the annual mean maximum path width does not show a downward trend, and in fact its three highest values occur in 2007, 2008, and 2011.

To better evaluate the destructive potential of significant tornadoes (at the time of their maximum intensity), a method was adopted to assign the median wind speed for each EF-scale rating to each tornado event from 1953 to 2012, after adjustments were made to the 1953–74 period. A simple plot of $PW_{\text{max}}$ versus $V_{\text{med}}$ shows a strong linear correlation ($r = 0.981$), with an approximately 170-m increase in $PW_{\text{max}}$ for each 10 m s$^{-1}$ increase in $V_{\text{med}}$. Also, the error-bar analysis presented supports the validity of this relationship.

Considerable attention in the past has been given to $u$, $v^2$, and $w^2$ when examining possible tornado destruction. This study has chosen $v^2$ to calculate an adjusted kinetic energy value for the entire period of 1953–2012, which shows a stationary record (with the exception of two outliers, 1974 and 2011). The adjusted kinetic energy is given respectively for 1953–73 and 1974–2012 as $1.23 \times 10^6$ and $1.40 \times 10^6$ m$^2$ s$^{-2}$ per significant tornado event per year. Recognizing that the destructive potential from significant tornadoes should consider both maximum wind speed and maximum size for the total annual record, a new parameter, tornado destruction index, has been defined as $(V_{\text{med}} \times PW_{\text{max}})^2$. This parameter is calculated for a unit area at the time of its maximum intensity, using the median value of the assigned EF-scale rating. Further, the annual cumulative total of TDI (defined as TDI$_C$) has been presented to evaluate the magnitude of destruction of significant tornadoes and shows a quasi-stationary pattern yet captures three record high events in the past 6 yr (2007, 2008, and 2011). This also illustrates the potential value of TDI$_C$ in monitoring the climatological trend of any increasing risk of tornado destruction, an important consideration in the climate science community today.

REFERENCES


Hales, J. E., 1988: Improving the watch/warning system through the use of significant event data. Preprints, 24th Conf. on Severe Local Storms, Baltimore, MD, Amer. Meteor. Soc., 165–168.


Soils are the largest terrestrial carbon pools and contain approximately 2200 Pg of carbon. Thus, the dynamics of soil carbon plays an important role in the global carbon cycle and climate system. Earth System Models are used to project future interactions between terrestrial ecosystem carbon dynamics and climate. However, these models often predict a wide range of soil carbon responses and their formulations have lagged behind recent soil science advances, omitting key biogeochemical mechanisms. In contrast, recent mechanistically-based biogeochemical models that explicitly account for microbial biomass pools and enzyme kinetics that catalyze soil carbon decomposition produce notably different results and provide a closer match to recent observations. However, a systematic evaluation of the advantages and disadvantages of the microbial models and how they differ from empirical, first-order formulations in soil decomposition models for soil organic carbon is still lacking. This study consists of a series of model sensitivity and uncertainty analyses and identifies dominant decomposition processes in determining soil organic carbon dynamics. Poorly constrained processes or parameters that require more experimental data integration are also identified. The critical role of microbial life history trait, such as microbial dormancy, in the modeling of microbial activity in soil organic matter decomposition models is also demonstrated through ablation analysis. Finally, this study also surveys and synthesizes a number of recently published microbial models and provides suggestions for future microbial model developments.

Towards a Paradigm Shift in the Modeling of Soil Organic Carbon Decomposition for Earth System Models

Yujie He
PhD Candidate

Tuesday, October 21, 2014
4:00 p.m.
Room 2201 HAMP

Refreshments at 3:30 pm
Room 2201/HAMP
Remote sensing methods such as interferometric synthetic aperture radar (InSAR) allow observations of surface properties over large areas at regular time intervals. InSAR, in particular, provides information about ground deformation, properties of the ionosphere and troposphere, as well as changes in surface characteristics such as vegetation and soil moisture. As higher-quality InSAR datasets become available, the spatial scale and magnitude of signals that can be studied has continued to be refined - this also requires more rigorous analysis to ensure that all of the potential contributions to the InSAR observations can be distinguished.

Here, I describe several anthropogenic signals that can be observed in InSAR, including logging, geothermal power production and mining, and focus on a magnitude 3.2 earthquake that was felt widely across the Chicago area last November. This earthquake was likely triggered by a blast at a gravel quarry, since it occurred at very shallow depth several seconds after the blast. I describe the constraints we can place on the earthquake source from InSAR and assess the consistency with seismic observations for this event.
Giant Impacts on the Asteroid 4 Vesta

Timothy Bowling
PhD Candidate

The geologically recent (~1 Gya) Rheasilvia basin on asteroid 4 Vesta is one of the most spectacular impact structures in the solar system, with a diameter nearly equal in size to that of Vesta itself. To date, much of the numerical modeling of this impact has concentrated on the morphology of the Rheasilvia basin. However, the stress wave produced by an impact of this size is capable of causing deformation at considerable distance from the basin itself. We use high resolution hydrocodes modeling coupled with a strain analysis routine in order to understand the modes and magnitudes of deformation expected globally on Vesta following the Rheasilvia impact. These simulations give insight into several interesting observations by NASA’s Dawn spacecraft. First, our results suggest that the major system of graben circling Vesta’s equator opened shortly after the passage of the Rheasilvia related impact shock wave. Secondly, we find that the deficiency of small craters at Vesta’s north pole is likely a result of antipodal focusing of Rheasilvia impact related stresses. The details behind both of these findings are dependent on material parameters of Vesta’s interior, including core strength, mantle porosity, and damage to the body from previous major impacts. By matching model output to observation, we can perform a crude sort of seismology and gain insight.
Sept. 4 When Engineering Geology Meets Geotechnical Engineering  
Gary Luce, Knight Piesold & Co., AEG President           Host: West

Sept. 9 The Impact of Climate Change and Agricultural Activities on Water Cycling in Northern Eurasia  
Yaling Liu, PhD Candidate             Advisor: Zhuang

  Tuesday, 4:00PM, Room 2201/HAMP

Sept. 11 The DOE Accelerated Climate Modeling for Energy Project  
Dr. Robert Jacob, Argonne National Laboratory           Host: Harshvardhan

Sept. 18 The Origins of Volatile-rich Solids and Organics in the Outer Solar Nebula  
Prof. Fred Ciesla, University of Chicago           Host: Minton

Sept. 25 Long-term Morphological Changes in Mature Supercell Thunderstorms Following Merger with Nascent Supercells  
Prof. Ryan Hastings, Purdue University

Sept. 30 Making Weather and Climate Data More Usable for Agriculture Across the U.S. Corn Belt  
Olivia Kellner, PhD Candidate             Advisor: Niyogi

  Tuesday, 4:00PM, Room 2201/HAMP

Oct. 2 New Perspectives on Tidewater Glacier Mass Change  
Dr. Tim Bartholomaus, University of Texas-Austin           Host: Elliott

Oct. 9 Sulfur Cycling on Mars from a Perspective of Sulfur-Rich Terrestrial Analogs  
Prof. Anna Szynkiewicz, University of Tennessee           Host: Horgan

Oct. 16 Climate Impacts and Extremes in Large Earth System Model Ensembles  
Prof. Ryan Sriver, University of Illinois-Champaign/Urbana           Host: Wu

Oct. 21 Towards a Paradigm Shift in the Modeling of Soil Carbon Decomposition for Earth System Models  
Yujie He, PhD Candidate             Advisor: Zhuang

  Tuesday, 4:00PM, Room 2201/HAMP

Oct. 23 Anthropogenic Signals in InSAR  
Prof. Rowena Lohman, Cornell University           Host: Elliott/Flesch

Oct. 28 Giant Impacts on the Asteroid Vesta  
Tim Bowling, PhD Candidate             Advisor: Melosh

  Tuesday, 4:00PM, Room 2201/HAMP

Oct. 30 Abiotic and Biogeochemical Controls on Reactive Nitrogen Cycling on Boundary Layer Surfaces  
Prof. Jonathan Raff, Indiana University           Host: Shepson

(continued on next page)
Nov.  6  Andean Foreland Basins: A Thermochronologic Perspective on Sediment
    Provenance, Deformation, and Basin Thermal Histories
    Prof. Julie Fosdick, Indiana University  Host: Ridgway

Nov.  11 Profiling Developing Tropical Storm Environments Using GPS Airborne
      Radio Occultation
      Brian Murphy, PhD Candidate  Advisor: Sun/Haase
      Tuesday, 4:00PM, Room 2201/HAMP

Nov.  13 Shale Gas Development and the Environment
    Prof. Mark Zoback, Stanford University  Host: Nowack
      Thursday, 4:00pm, Room 210/MTHW (joint with the Physics Dept.)

Nov.  20 The Role of Monsoon Circulation on Tropopause Variability
    Prof. Yutian Wu, Purdue University

Dec.   4  CSI Patagonia: Tracking Glacial and Climate Dynamics over the Last Glacial Cycle
    Alessa Geiger, University of Glasgow  Host: Harbor
LOOKING FOR A POSITION TO PUT YOUR LANGUAGE AND TECHNICAL SKILLS TO USE?

BILINGUAL STUDENT CAREER FAIR

NOV. 4 | 10AM-3PM
FRANCE CORDOVA RECREATIONAL CENTER

NETWORKING RECEPTION

NOV. 3 | 5-8PM
DAUCH PURDUE ALUMNI CENTER

5-6PM NETWORKING WORKSHOP

6:30-7:30PM “BRANDING YOUR MULTICULTURALISM” KEYNOTE SPEAKER

7:30-8PM PRACTICE NETWORKING

The capacity for this event is limited and will be on a first come, first serve basis. Please RSVP to “Bilingual Career Fair Networking Event” workshop through your myCCO account starting Oct 1st 2014.

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A Travel Grant has been established by a donor to provide $500 in travel funds for an EAPS graduate student to attend and present at any American Meteorological Society (AMS) meeting. This call is for travel to AMS meetings that will be held in 2015.

For a list of AMS meetings, see http://www.ametsoc.org/MEET/index.html.

The $500 travel award is limited to EAPS graduate students who plan to make an oral or poster presentation at any AMS meeting. Students may apply in advance of their paper/poster being accepted. Should a student be awarded the travel grant and their paper/poster is not accepted, the travel monies will be forfeited and will be made available to another student (at the discretion of the award selection committee).

Students need to provide electronic files via email attachment to Kathy Kincade (kkincade@purdue.edu) including the cover sheet (2nd page of this document), an abstract and title of the proposed presentation, and an advisor’s letter of nomination by the required due date to be considered.

The awardee will be selected by a faculty committee appointed by the Head. Awardees must submit a travel request a minimum of two weeks before departure using the standard departmental travel procedures - see the Business Office for details. The funds will be provided as reimbursement for normal travel expenses.

The complete application must be submitted electronically to Kathy Kincade (kkincade@purdue.edu) by 5:00 PM on Thursday, October 30, 2014.
APPLICATION

2015 AMS Travel Grant for EAPS Grad Students

Graduate Student’s Name__________________________________________

Level (circle one) PhD MS

Faculty Advisor______________________________________________________

Grad Program GPA (or undergrad GPA if less than one year at Purdue) ________

AMS Meeting Title___________________________________________________

AMS Meeting Date___________________________________________________

The complete application must be submitted electronically to Kathy Kincade (kkincade@purdue.edu) by 5:00 PM on Thursday, October 30, 2014.
P. F. Low AGU Travel Award Competition for EAPS PhD Students

The P. F. Low AGU Travel Award is sponsored by Professor Cushman to provide travel funds for one EAPS PhD student to make a presentation at the Fall (San Francisco, CA) American Geophysical Union (AGU) meeting. The award is named in honor of the late Philip F. Low, a member of the National Academy of Sciences and a pioneer in the rigorous use of thermodynamics for the study of clay-water interactions.

A travel award of (up to) $1000 will be awarded to support one EAPS student to present at the AGU fall meeting. Funds will be provided as reimbursement for normal travel expenses.

Awards will be made based on merit of the research project, as well as on financial need. Students need to electronically provide the cover sheet (see below), an abstract of the proposed presentation, and an advisor’s letter of nomination by the required due date to be considered.

The complete application must be submitted electronically to Kathy Kincade (kkincade@purdue.edu) by 5:00pm, Thursday, October 30, 2014.
APPLICATION

P. F. Low AGU Travel Award Competition for EAPS PhD Students

PhD Student’s Name__________________________________________

Faculty Advisor______________________________________________

Grad Program GPA (or undergrad GPA if less than one year at Purdue) _________

List other sources of funding and amount anticipated:

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The complete application must be submitted electronically to Kathy Kincade (kkincade@purdue.edu) by 5:00 PM on Thursday, October 30, 2014.
Glaciation in Sweden

Study Abroad Course, May 4 – June 5, 2015
3 credits: Estimated maximum cost $3,000, including tuition, all travel, food, and lodging (university and college study abroad scholarships may reduce this cost significantly)

Interested? Please send an email asap to the instructor at jharbor@purdue.edu letting him know you are interested. Expressing interest is not a commitment to take part in the program. This program will only be offered if there are enough students interested. If at least six people have expressed interest by October 25th we will hold an information session to discuss the details.

Glaciation in Sweden focuses on reconstructing past glacial history based on an understanding of glacial processes combined with evidence from landforms and sediments. It involves course and fieldwork jointly with students taking an equivalent course at Stockholm University. This course is intended for juniors and seniors majoring in geology, as well as graduate students with interests in geomorphology and Quaternary geology.

The study abroad course will run from May 4th to June 5th (May 4th – May 21st in West Lafayette, May 21st to June 5th in Sweden), and will include:

1. **Pre-Departure.** On campus lectures, readings, and assignments to provide a foundation in how glaciers work, glaciers and climate change, and reconstructing past glaciers. This will include a small group project using remote sensing to map glacial landforms in a field area prior to fieldwork.

2. **Cultural Program.** The first stage of the study abroad component will involve learning about the history and culture of Stockholm (from Vikings to ABBA and beyond), and learning about the life and education of Swedish students in meetings with Stockholm University students and faculty. We will also learn about the geologic history of Stockholm and how it has shaped the city and its history. This phase will also allow us to get over jet lag before the field program. Between the field program and the final coursework at Stockholm University, we will have a weekend free for additional cultural experiences. The Stockholm Marathon occurs this weekend, in case this interests you.

3. **Field Program.** We will take part in a joint field program to the southern Swedish Mountains, run by Stockholm University, for five days. The field course focuses on investigating geological evidence for past glaciation and uses advanced techniques in the geosciences. This involves extended visits to field sites, observations, measurement, collection of samples, and analysis of data. We will work in small groups that include both Purdue and Stockholm students on projects that tie into the pre-departure mapping of glacial landforms using remote sensing.

4. **Project Presentations at Stockholm University.** Following the field program the Purdue and Stockholm students will work together to finalize their team projects and associated reports and will jointly deliver oral presentations on their projects at the end of the course.

Return to the US is on June 5th, however participants may choose to extend their stay in Europe to travel on their own or in groups (not part of the study abroad).