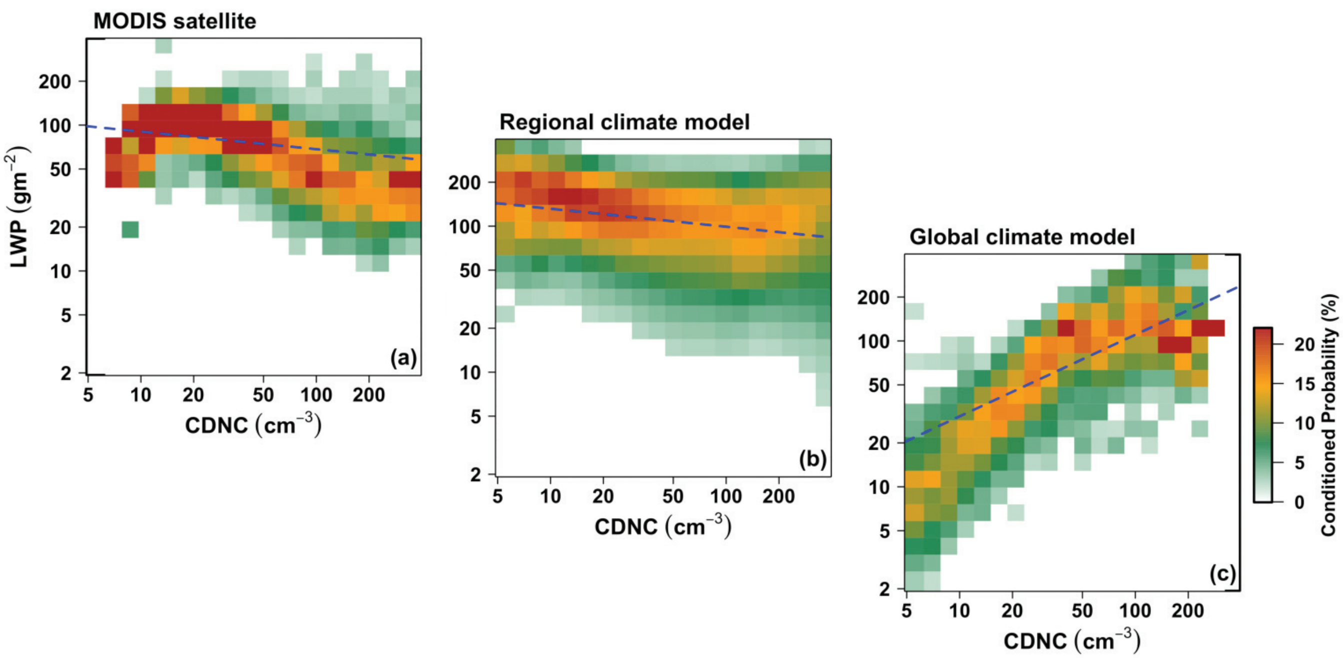
GEWEX NEWS

GEWEX is a Core Project of WCRP on Global Energy and Water Exchanges

WCRP World Climate Research Programme | WMO | UNESCO | IOC | ICSU International Council for Science

Vol. 27 No. 2, May 2017

Workshop Reviews Aerosols-Clouds-Precipitation-and-Climate (ACPC) Initiative Progress in Case Studies



Initial results from Dipu Sudhakar, University of Leipzig show similarities to the satellite-derived relationships in some models, but not in all. Statistical relationship between cloud liquid water path (LWP) and cloud droplet number concentration (CDNC) expressed as conditioned probability (sum of LWP probability for each class of CDNC is normalized to unity as in Gryspeerdt et al. 2016) for the Variability of the American Monsoon System (VAMOS) Ocean-Cloud-Atmosphere-Land Study (VOCALS) region and period, from (a) MODIS satellite retrievals, (b) a regional climate model and (c) a global climate model. The dashed blue line shows the linear regression between the two quantities. See article by Johannes Quaas et al. on page 7.

Contents

Commentary

Global Energy and Water Exchanges in Times of Change

Sonia I. Seneviratne
Co-Chair, GEWEX Scientific Steering Group (SSG), Professor for Land-Climate Dynamics, ETH Zürich, Switzerland

This issue of *GEWEX News* illustrates the ever-evolving nature and dynamism of the research performed within the GEWEX community. First, we are happy to welcome Prof. Paul Dirmeyer as a new GEWEX SSG member, and Dr. Daniel Klocke and Prof. Xubin Zeng as new co-chairs of the Global Atmospheric System Studies (GASS) Panel. Paul Dirmeyer has been a long-standing and pioneering member of the GEWEX community and it is thus a great pleasure that he can join the SSG and help steer new developments within our core project. The new GASS co-chairs will lead and redesign the GASS Panel, which will include adding stronger ties to the World Weather Research Programme. As highlighted in the recent World Climate Research Programme (WCRP) workshop, "Climate Science: Thinking Out of the Box," developing research at the interface between weather and climate science constitutes one of the promising new frontiers for climate research (Marotzke et al., 2017).

The activities and workshop reports in this newsletter exemplify the diversity and innovative nature of current GEWEX initiatives, which range from the evaluation of upper tropospheric clouds and convection (page 4) to aerosol effects on shallow and deep clouds (page 7), to the analysis of multivariate extremes and compound events (page 10). The latter topic is a new focus area of the WCRP Grand Challenge on Weather and Climate Extremes, of which GEWEX is a co-leader.

It is also a great pleasure to see the successful development of the Pannonian Basin Experiment (PannEx), which is working towards becoming a new Regional Hydroclimate Project of the GEWEX Hydroclimatology Panel (page 9). The Pannonian Basin is a key agricultural and climate region in Central and Eastern Europe, located in a hot spot of climate change. For this reason, the developed research and monitoring program is of crucial relevance, in terms of both fundamental climate science and climate applications.

While embracing these new areas of development, we should also applaud long-standing successful GEWEX activities, such as the Baseline Surface Radiation Network (page 3). We are thankful to the visionary initiators of this network, including Atsumu Ohmura, Professor Emeritus of ETH Zürich, and to the Alfred Wegener Institute for its current invaluable support.

These and a wealth of other ongoing GEWEX activities were presented at the annual Joint Scientific Committee (JSC) meeting of WCRP held in early April. Potential joint initiatives within WCRP programs were discussed, and one of particular interest was the proposal for assessments of the global energy and water balance as a measure of ongoing climate change by the Climate and Ocean Variability, Predictability and Change (CLIVAR) Project and GEWEX.

Looking at the many GEWEX projects bringing researchers together across the world, we should be mindful that cooperation moves science forward. Being diligent and innovative is essential in these times of changing political views, and we should be watchful that science is recognized for what it is: the search for truthful understanding, and not a matter of belief. We should be vigilant in ensuring that the merit of international research collaboration is recognized at its true value.

Reference

Marotzke, J., C. Jakob, S. Bony, P. A. Dirmeyer, P. A. O'Gorman, E. Hawkins, S. Perkins-Kirkpatrick, C. Le Quéré, S. Nowicki, K. Paulavets, S. I. Seneviratne, B. Stevens and M. Tuma, 2017. Climate research must sharpen its view. *Nature Climate Change*, 7, 89–91.

Paul A. Dirmeyer—New GEWEX Scientific Steering Group Member

We welcome Paul A. Dirmeyer as a new member of the GEWEX SSG. He is a Professor and Senior Research Scientist at the Center for Ocean-Land-Atmosphere Studies at George Mason University in Fairfax, Virginia, USA. Dr. Dirmeyer was a co-founder and former chair of the Global Land/Atmosphere System Study (GLASS) Panel and leader of the Global Soil Wetness Project (GSWP). His scientific interests lie in the role of the land surface in the climate system. This includes the development and application of land-surface models, studies of the impact of land surface variability on the predictability of climate, interactions between the terrestrial and atmospheric branches of the water and energy cycles and the impacts of land use change on regional and global climate.

For a listing of all the GEWEX SSG members, see: *http://www.gewex.org/about/organization/*.

Changes in Leadership in GASS Panel

The new co-chairs for the Global Atmospheric System Studies (GASS) Panel are Drs. Daniel Klocke and Xubin Zeng. GASS coordinates studies related to atmospheric and radiative processes.

Dr. Daniel Klocke is the research area director at the Hans Ertel Center for Weather Research at the German Weather Service in Offenbach, Germany. Dr. Klocke is a meteorologist with research interests in atmospheric modeling for weather and climate across spatial scales with a focus on convection. Previously he worked at the European Centre for Medium-Range Weather Forecasts and the Max Planck Institute for Meteorology.

Dr. Xubin Zeng is the Agnese N. Haury Chair for Environment, Professor of Atmospheric Science, and Founding Director of the Climate Dynamics and Hydrometeorology Center at the University of Arizona in Tucson, Arizona, USA. His research interests include land-atmosphere-ocean interface processes, climate modeling, hydrometeorology, remote sensing and nonlinear dynamics.

Director of WRMC Retires

Dr. Gert König-Langlo, the Director of the World Radiation Monitoring Center (WRMC) from 2008–2017, retired in April. WRMC hosts the Baseline Surface Radiation Network (BSRN) archive. We thank Dr. König-Langlo for his dedicated years of participation in BSRN and his excellent leadership in establishing and running the WMRC at the Alfred Wegener Institute (AWI) for Polar and Marine Research at Bremerhaven in Germany. Dr. Amelie Driemel, who has been the data curator for the BSRN archive for several years, has assumed the role of Director of the WRMC.

From left to right: Atsumu Ohmura (architect of BSRN archive and first director of WRMC), Gert König-Langlo and Amelie Driemel.

News from the Young Earth System Scientists (YESS) Community

Carla Gulizia and the YESS Council
Centro de Investigaciones del Mar y la Atmósfera (CIMA/CONICET-UBA), Buenos Aires, Argentina

YESS is a unified international multidisciplinary Early Career Researcher (ECR) network with more than 900 members from over 80 countries. It works closely with international programs for active involvement of ECRs in leading scientific programs and participates and organizes special ECR events at international scientific meetings.

A YESS office was established at the Argentinian National Weather Service in Buenos Aires in March 2017. Valentina Rabanal, the YESS officer, will assist in coordinating and strengthening the YESS community. This represents a big step forward to engage more ECRs and to build the YESS community on international and interdisciplinary levels.

YESS annual elections took place in April 2017 and Regional Representatives and the Executive Committee were elected by the YESS Council members. Regional Representatives support the YESS community by sharing experiences, special interests or information from their region. They are responsible for the growth of YESS in their region and serve as the contact points for specific regional questions, activities and tasks. The YESS community currently has representatives for the following regions: Africa, Central Asia, Europe, North America, South America, South East Asia and the South West Pacific. The outcomes of the elections are available on the YESS website at: *http://www.yess-community.org*.

YESS activities include organizing "scientific speed dating" for ECRs at the 2017 European Geophysical Union General Assembly. This activity is aimed at sharing scientific questions and establishing potential collaborations. Two YESS Council members were invited to represent YESS membership in the ECR Network of Networks (ECR NoN) at the Future Earth Science and Engagement Committee meeting in March 2017. In April 2017, the 38th Session of the Joint Scientific Committee (JSC) of the World Climate Research Programme was held in Paris, France, and YESS members presented their achievements, plans for the coming year and recommendations for consideration by the JSC. YESS was also invited to present at the "Women in Science–Breaking the Cliché" event at the World Meteorological Organization in Switzerland in May 2017. Want to know more about YESS or join our community? Visit our website or follow us on Facebook, Twitter and LinkedIn.

Recently publish a paper related to GEWEX research?

If your research qualifies, highlights from it may be published on the GEWEX website or featured in *GEWEX News*. For consideration, please summit your research highlight at: *http://www.gewex.org/latest-news/research-highlights/*.

Process Evaluation Study on Upper Tropospheric Clouds and Convection (UTCC PROES)

Claudia Stubenrauch[1], Graeme Stephens[2] and GEWEX UTCC PROES Working Group

[1]Laboratoire de Météorologie Dynamique/Institut Pierre Simon Laplace, Centre National de la Recherche Scientifique, University Pierre and Marie Curie, Paris, France; [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

The goal of activities of the GEWEX Process Evaluation Study (PROES) is to provide observation-based metrics for a better understanding of climate-related physical processes and to advance their representation in research, weather and climate models. A process that affects many components of the Earth system is convection. This process is a fundamental mode of mixing and transport, moving heat, moisture, momentum and atmospheric constituents through the Earth's atmosphere. Convective storms are the sole source of precipitation in many regions of our planet and are widely understood to play a vital role in the Earth's weather and climate. Advancing our understanding of these storm systems is viewed as one of the major challenges for atmospheric sciences in the coming decade (Bony et al., 2015). Convection is also a topic that is central to various national agency objectives seeking to "improve the capability to predict weather and extreme weather events."

The GEWEX Upper Tropospheric Clouds and Convection (UTCC) PROES initiative specifically aims to develop new diagnostic methods using existing observations to examine the processes that detrain Upper Tropospheric (UT) clouds from convection and the interconnection between convection and the radiative heating induced by outflowing cirrus anvil clouds. This heating is affected by at least three factors:

1. areal coverage of UT clouds,
2. cloud emissivity within the UTC systems, and
3. underlying structure.

Since we are also interested in the thinner part of anvil clouds, we use cloud properties obtained from the Atmospheric Infrared Sounder (AIRS) and the Infrared Atmospheric Sounding Interferometer (IASI), because their spectral resolution provides reliable cirrus identification, day and night.

There currently are no real constraints in modeling the processes that produce these UT clouds, which results in a large model-to-model spread in UT cloud properties and their related feedbacks in models. While many feedbacks built around the UT cloud radiative effects have been hypothesized, UTCC PROES was founded on the hypothesis that the radiative heating of the atmosphere specifically associated with UT clouds is fundamental to the most important cloud-convection-climate feedbacks. Thus, an important outcome of the UTCC activity is the relationship between convection and the radiative heating associated with the UT clouds produced by convection.

UTCC PROES Goals

- Understand and quantify the relation between convection and outflowing cirrus anvils by developing observation-based metrics.
- Determine the radiative heating of the UTC systems and quantify related feedbacks between UT clouds and convection in order to evaluate these processes in models.

Important UTCC PROES Elements

- Develop new observational diagnostics designed specifically to address UTCC goals.
- Apply these diagnostics to evaluate and improve parameterizations affecting the relationships between convection and UT clouds in both cloud-resolving and global weather and climate models.
- Develop process study experiments with these models, including transport models, to strengthen our understanding of the processes critical to representing the response of UT clouds to changes in environmental forcing.

A working group is being formed that links, at present, about 50 scientists from different communities. The first UTCC PROES workshop was held at the Pierre and Marie Curie University (UPMC) in Paris, France in November 2015. Twenty participants presented and discussed feedback hypotheses and resources related to cloud systems and atmospheric environment from observations, Lagrangian transport to determine cirrus origin and life cycle, process modeling and large-scale parameterizations and radiative transfer. Further meetings during the International Radiation Sym-

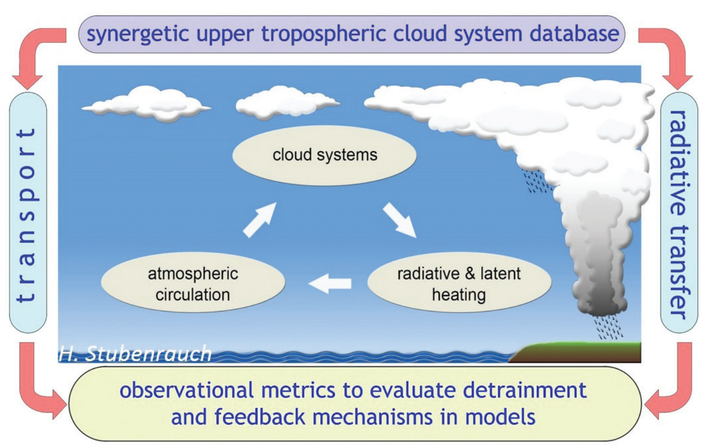


Figure 1. Main elements (ovals) and links in the cloud feedback problem, framed by the synergetic elements necessary to determine UT cloud feedback mechanisms by advancing our understanding on these cloud systems.

posium in Auckland, New Zealand, and at UPMC in Paris, France in April 2016 provided forums for discussing strategies and first results. The goal of the second workshop, which was held at City College, University of New York (CUNY) in New York on 28–29 March 2017, was to outline the next steps of UTCC PROES, including bringing diagnostic observations to cloud resolving models (CRMs) and general circulation models (GCMs).

UTCC PROES Synergistic Data

In addition to existing databases, such as the Tropical Rainfall Measuring Mission (TRMM), Megha-Tropiques and the International Satellite Cloud Climatology Project (in particular, statistics on weather states), which have been extensively used to study tropical mesoscale convective systems, UTCC PROES will provide:

- A new database of UT cloud systems created from AIRS and IASI cloud top pressure (Protopapadaki et al., 2017) with horizontal extent, and more importantly, emissivity distributions within these systems, will aid in distinguishing between thin cirrus, cirrus anvil and deep convective cores;
- The vertical dimension of the A-Train satellite constellation lidar-radar track using CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) mission data, including vertical cloud extent and layering, height of ice phase and ice water content and effective ice crystal diameter (De) profiles, as well as radiative heating rates;
- Thermodynamic and dynamic information from meteorological reanalyses; and
- Additional geostationary cloud data (e.g., data developed for Megha-Tropiques) placed in the context of the life cycle of these systems (formation, maturity and dissipation).

UTCC PROES First Observational Metrics

Measures of convective intensity, strength and depth may be given by vertical updraft, lightning flash rate, level of neutral buoyancy, area of heavy rainfall, width of the convective core, cold cloud top temperature and mass flux (see references in Protopapadaki et al., 2017). UTCC PROES is performing a review of the different merits of these properties and how they might relate to precipitation (e.g., Figure 10 in Protopapadaki et al., 2017) and other properties of convection.

The first UTCC PROES results are expected to provide new diagnostic characterizations of the convective detrainment process. Two mutually supporting examples of these are linking anvil properties to different proxies of convective depth (see Figures 2 and 3). Both of these analyses reveal the remarkable result that for mature tropical convective cloud systems, the ratio of thin cirrus over total anvil area (thick and thin cirrus) increases (AIRS data) as convective depth increases. For the latter, two independent proxies are used—the minimum

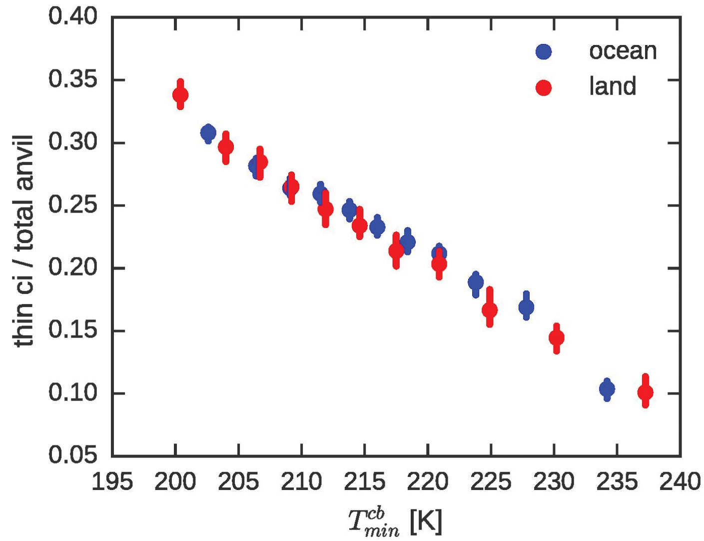


Figure 2. Thirteen years of statistics from AIRS. The ratio of thin cirrus (emissivity < 0.5) to total cloud anvil area of convective systems increases as the temperature of the convective core (emissivity > 0.98) decreases. The latter is a measure of convective depth (from Protopapadaki et al., 2017).

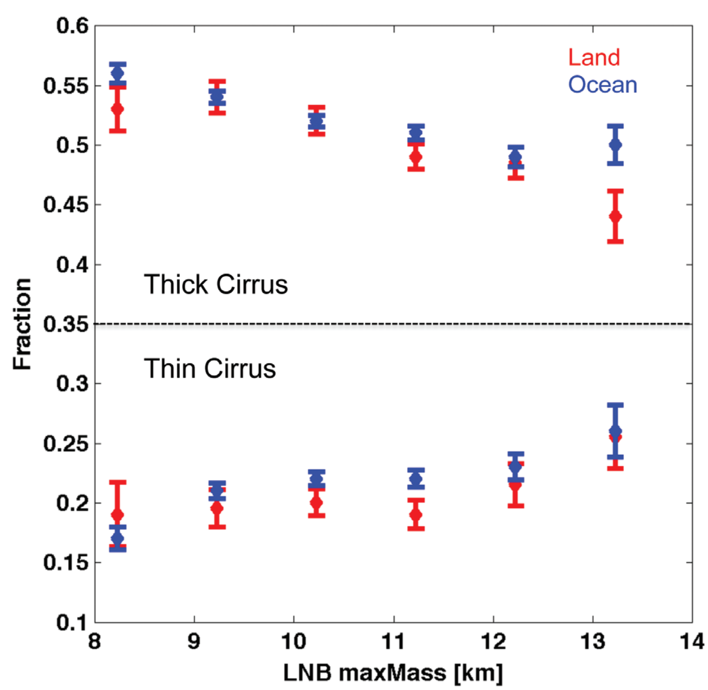


Figure 3. Three years of collocated AIRS-CloudSat convective cloud systems statistics. The fraction of thick cirrus and thin cirrus within the total anvil areas of convective systems decrease and increase, respectively, as the height of the maximum mass flux within the anvil increases. (H. Takahashi et al., presented at UTCC PROES workshop).

cloud top temperature within the convective core from AIRS (Figure 2) and the height of the level of neutral buoyancy maximum mass flux derived from CloudSat (Figure 3). These different analyses suggest that the behavior of UT cloud properties with increasing convective strength is robust.

Next Steps for UTCC PROES

These first observational metrics can be used to evaluate detrainment processes in models. Thus, the second workshop had a greater emphasis on modeling than earlier UTCC PROES meetings (see program at: *http://www.gewex.org/gewex-content/uploads/2017/03/UTCC_PROES_Meeting.pdf*). Steps towards using CRM simulations were outlined, along with strategies to evaluate GCM convective parameterizations, including entrainment and detrainment. Since the mechanism(s) responsible for the observed behavior of UT clouds revealed in Figures 2 and 3 are not yet understood, CRM experiments are now being planned to simulate the observations and investigate possible mechanisms.

An important part of the project has to do with the heating rates of UT cloud systems. As a first step, these mechanisms will be sorted per cloud type (with respect to cloud emissivity) within UT cloud systems by propagating the lidar-radar nadir track vertical structure information across AIRS-observed UT cloud systems. A simulator for UT cloud systems was developed for the evaluation of the Laboratoire de Météorologie Dynamique climate model and can be adapted for CRM studies and for the evaluation of other GCMs.

During the workshop, it was noted that an important observational constraint is the vertical velocity profile. An interesting strategy to study the evolution of tropical convection is compositing a measure of vertical velocity estimated from CloudSat against the TRMM convection time series (Masunaga and Luo, 2016).

To find out how much of the heating can be traced to convectively generated cirrus, we need to separate cirrus systems (UT cloud systems not containing convection) originating from convection and in situ freezing. Since the A-Train observations provide only snapshots, Lagrangian transport studies will have to be performed. In addition, the evolution of cloud systems could be investigated over specific regions (e.g., the West Pacific Warm Pool) by adding high temporally-resolved information from geostationary imagers.

The next UTTC PROES workshop is scheduled for autumn 2018. However, shorter meetings are foreseen during international conferences.

References

Bony, S., B. Stevens, D. M. W. Frierson, C. Jakob, M. Kageyama, R. Pincus, T. G. Shepherd, S. C. Sherwood, A. P. Siebesma, A. H. Sobel, M. Watanabe and M. J. Webb, 2015. Clouds, Circulation and Climate Sensitivity. *Nat. Geosci.*, 8, 261–268.

Masunaga, H., and Z. J. Luo, 2016. Convective and large-scale mass flux profiles over tropical oceans determined from synergistic analysis of a suite of satellite observations. *J. Geophys. Res. Atmos.*, 121, doi:10.1002/2016JD024753.

Protopapadaki, E.-S., C. J. Stubenrauch and A. Feofilov, 2017. Upper Tropospheric Cloud Systems Derived from IR Sounders: Properties of Cirrus Anvils in the Tropics. *Atmos. Chem. Phys.*, 17, 3845–3859, doi:10.5194/acp-17-3845-2017.

Participants of the 2nd UTCC PROES Workshop at City College, University of New York.

First Results from ACPC Case Studies on Aerosol Effects on Shallow and Deep Clouds

Johannes Quaas[1], Daniel Rosenfeld[2], Meinrat Andreae[3], Graham Feingold[4], Ann Fridlind[5], Ralph Kahn[6], Philip Stier[7], Kentaroh Suzuki[8], Sue van den Heever[9] and Robert Wood[10]

[1]University of Leipzig, Germany; [2]Hebrew University of Jerusalem, Israel; [3]Max Planck Institute for Chemistry, Mainz, Germany; [4]NOAA Earth System Research Laboratory, Boulder, USA; [5]NASA Goddard Institute for Space Studies, New York, USA; [6]NASA Goddard Space Flight Center, Greenbelt, USA; [7]University of Oxford, United Kingdom; [8]University of Tokyo, Japan; [9]Colorado State University, Fort Collins, USA; [10]University of Washington, Seattle, USA

The Aerosols-Clouds-Precipitation-and-Climate (ACPC) Initiative aims at a better understanding and quantification of the impact of aerosol perturbations on clouds, radiation, precipitation, latent heating and atmospheric circulation. Following roadmaps defined and iterated at earlier meetings (see: *http://research.uni-leipzig.de/acpc/meeting2017.html* and summarized in workshop reports, Quaas et al., 2015; 2016), and a comprehensive review paper summarizing earlier work within ACPC (Rosenfeld et al., 2014), the initiative focuses on two cloud regimes—shallow marine clouds and deep convective clouds. Ongoing work and recent results were discussed at a workshop held at the Physikzentrum Bad Honnef in Germany from 2–6 April 2017.

Research on deep convective clouds is currently focused on isolated convective cells over Houston, Texas, USA. This research is guided by the substantial perturbation in cloud condensation nuclei (CCN) concentrations caused by pollution from Houston in onshore flow that is in contrast to much less polluted conditions in the vicinity as observed by new satellite products (Rosenfeld et al., 2016). The aerosol perturbation under onshore flow conditions offers the possibility of observing the evolution of convective cells under relatively uniform thermodynamic conditions.

On the observations side, emphasis is placed on the analysis of radar measurements. Groups at the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS), Texas A&M University, the National Atmospheric and Oceanic Administration and the National Severe Storms Laboratory identified convective cells in polarimetric radar data from the Next-Generation Weather Radar (NEXRAD) network and tracked them over their lifetime. Preliminary analysis of the NEXRAD data and collocated Lightning Mapping Array observations indicate that characteristics of isolated cell evolution differ between situations subject to relatively high versus low CCN conditions. One study by the Texas A&M University and the Hebrew University of Jerusalem proposed from a statistical analysis of observations that these clouds had greater vertical development, larger hydrometeors and enhanced lightning, hypothesizing that this might be due to invigoration (Andreae et al., 2004; Rosenfeld et al., 2008). Through interaction with experts on radar observations, the group proposes new radar observation strategies that may allow for improved tracking of rapidly evolving cell development, in particular using mobile polarimetric radars that can offer rapid scan capabilities. A group at Stony Brook University and NASA GISS used forward simulation from preliminary simulations to demonstrate potential minimum requirements (distances from target, number of radars) for radars to adequately observe isolated cells and potentially retrieve vertical wind speed.

On the modeling side, a common case study protocol for simulations of deep convective clouds has been defined (details are available at: *www.acpcinitiative.org*) and first simulations were conducted with two cloud-resolving models. These simulations from Colorado State University and the University of Oxford showed distinct differences between the high- and low-CCN simulations in vertical wind and specific ice content, albeit with little signal in surface precipitation. This latter finding was also evident in an ensemble of simulations conducted by the University of Leeds for a different convective case, where it was very clear that even very large aerosol perturbations do not produce signals in precipitation distinguishable from the uncertainty range as represented by the ensemble spread. However, other properties differed notably but not entirely consistently across the models tested; such differences between models are expected based on substantial uncertainties in microphysics schemes (White et al., 2016), in part motivating a strong parallel effort on the observation side. Based on a new analysis of data from the air quality focused field study, Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ), by the Max Planck Institute for Chemistry, the prescribed CCN profiles of the case study protocol will be revised. A next step is to invite the wider modeling community to contribute more simulations and to forward-simulate polarimetric radar signals from the simulations for comparison to the hypotheses on aerosol signals proposed on the basis of the observations analysis.

Based on these results, ACPC is working towards a first field campaign where at least one mobile radar from potential U.S. sources can be deployed and the methods for rapid scanning and statistical assessment of the observations can be tested on site in the Houston area. The model simulations in the deep convective cloud case study will help to develop and test observational strategies for the field campaign; examples include testing the potential capability to measure wind convergence profiles using high-resolution dropsonde arrays over 100-km-diameter columns (based on preliminary results by the Laboratoire de Météorologie Dyanmique and Max Planck Institute for Meteorology) and assessing the observational strategy to achieve a box closure experiment (Rosenfeld et al., 2014).

With regard to shallow clouds, research has focused on the southeastern Pacific stratocumulus region, where the Variability of the American Monsoon System (VAMOS) Ocean-Cloud-Atmosphere-Land Study (VOCALS) field campaign made comprehensive measurements in October–November 2008. Statistical relationships between aerosol optical depth and cloud droplet number concentration, N_d, and between N_d and cloud liquid water path (LWP, Michibata et al., 2016) are being assessed from available simulations and satellite retrievals and put into the context of anthropogenic perturbation (cf. Gryspeerdt et al., 2017).

First results from the University of Leipzig show similarities to the satellite-derived relationships in some models, but not in all (see figure on page 1). From a set of simulations by the University of Leeds, new results suggest the possibility of identifying clear signals of anthropogenic effects on clouds even in top-of-atmosphere radiation (Grosvenor et al., 2017). A new effort is now directed at running large eddy simulations (LES) along Lagrangian trajectories derived from a coarse grid Weather Research and Forecasting (WRF) model. This amounts to a downscaling exercise in which a LES provides a more detailed view of aerosol and cloud processes along the stratocumulus to cumulus transition. Trajectories were initiated near the Chilean coast in closed cell stratocumulus decks under polluted conditions and followed towards the open ocean where the regime changed to broken cumulus cloudiness, with a corresponding reduction in aerosol loading. Sensitivity to WRF forcing has been explored but much more work needs to be done.

The Shallow Cloud Working Group, along with continuing research along these lines, will broaden the focus to also consider stratocumulus and their transition to cumulus in the Southeast Atlantic under the influence of biomass burning smoke [the Observations of Aerosols above Clouds and their interactions (ORACLES)/CLoud-Aerosol-Radiation Interactions and Forcing (CLARIFY)/Layered Atlantic Smoke Interactions with Clouds (LASIC) campaigns]; also trade-wind cumulus clouds will be observed along with a comprehensive characterization of the large-scale weather conditions in the Elucidating the Role of Cloud-Circulation Coupling in Climate (EUREC4A) campaign (*http://eurec4a.eu/*). Finally, because the Shallow Cloud Group to a large extent assesses satellite data, one ongoing effort within ACPC is to characterize capabilities and uncertainties of current cloud droplet number concentration calculations based on satellite-based cloud optical depth and drop effective radius retrievals, and to assess new and upcoming approaches.

A follow-up workshop is planned for 4–6 April 2018 in Colorado, USA. The ACPC group welcomes interested persons or groups to join the activities.

References

Andreae, M. O., D. Rosenfeld, P. Artaxo, A. A. Costa, G. P. Frank, K. M. Longo and M. A. F. Silva-Dias, 2004. Smoking rain clouds over the Amazon. *Science*, 303, 1337–1342, doi:10.1126/science.1092779.

Grosvenor, D. P., P. R. Field, A. A. Hill and B. J. Shipway, 2017. The relative importance of macrophysical and cloud albedo changes for aerosol induced radiative effects in stratocumulus: insight from the modeling of a case study. *Atmos. Chem. Phys.*, 17, 5155–5183, doi:10.5194/acp-17-5155-2017.

Gryspeerdt, E., J. Quaas and N. Bellouin, 2016. Constraining the aerosol influence on cloud fraction. *J. Geophys. Res.*, 121, 3566–3583, doi:10.1002/2015JD023744.

Gryspeerdt, E., J. Quaas, S. Ferrachat, A. Gettelman, S. Ghan, U. Lohmann, H. Morrison, D. Neubauer, D. G. Partridge, P. Stier, T. Takemura, Hailong Wang, M. Wang and K. Zhang, 2017. How accurately can the forcing from aerosol-cloud interactions be constrained? *Proc. Nat. Acad. Sci.* USA, in press.

Michibata, T., K. Suzuki, Y. Sato and T. Takemura, 2016. The source of discrepancies in aerosol–cloud–precipitation interactions between GCM and A-Train retrievals, *Atmos. Chem. Phys*., 16, 15413–15424, doi:10.5194/acp-16-15413-2016.

Quaas, J., D. Rosenfeld, A. Fridlind and R. Wood, 2015. Workshop on the Aerosols-Clouds-Precipitation and Climate (ACPC) Initiative, *GEWEX News*, 25, No. 2, 11–12.

Quaas, J., D. Rosenfeld, A. Fridlind, R. Wood, G. Feingold, S. van den Heever and P. Stier, 2016. ACPC Initiative to identify signatures of aerosol-cloud interactions in high-resolution modeling and observations. *GEWEX News*, 26, No. 3, 5–7.

Rosenfeld, D., Y. T. Zheng, E. Hashimshoni, M. L. Pöhlker, A. Jefferson, C. Pöhlker, X. Yu, Y. N. Zhu, G. H. Liu, Z. G. Yue, B. Fischman, Z. Q. Li, T. Giguzin, T. Goren, P. Artaxo, H. M. J. Barbosa, U. Pöschl and M. O. Andreae, 2016. Satellite retrieval of cloud condensation nuclei concentrations by using clouds as CCN chambers, *Proc. Nat. Acad. Sci.* USA, 114 (21), 5828–5834.

Rosenfeld, D., M. O. Andreae, A. Asmi, M. Chin, G. Leeuw, D. P. Donovan, R. Kahn, S. Kinne, N. Kivekäs, M. Kulmala, W. Lau, S. Schmidt, T. Suni, T. Wagner, M. Wild and J. Quaas, 2014. Global observations of aerosol-cloud-precipitation-climate interactions. *Rev. Geophys.,* 52, 750–808, doi:10.1002/ 2013RG000441.

Rosenfeld, D., U. Lohmann, G. B. Raga, C. D. O'Dowd, M. Kulmala, S. Fuzzi, A. Reissell and M. O. Andreae, 2008. Flood or drought: How do aerosols affect precipitation?, *Science*, 321, 1309–1313, doi:10.1126/science.1160606.

White, B., E. Gryspeerdt, P. Stier, H. Morrison, and G. Thompson, 2016. Can models robustly represent aerosol–convection interactions if their cloud microphysics is uncertain? *Atmos. Chem. Phys. Discuss.* doi: 10.5194/acp-2016-760.

Submit an Article to be Published in *GEWEX News*

The GEWEX newsletter disseminates scientific research results and information related to GEWEX activities. If you are are interested in submitting an article, please see: *http://www.gewex.org/resources/gewex-news/submit-an-article/.*

Meeting/Workshop Reports

3rd PannEx Workshop

Cluj-Napoca, Romania
20–22 March 2017

Ivan Güttler[1] and Mónika Lakatos[2]

[1]Meteorological and Hydrological Service (DHMZ), Zagreb, Croatia; [2]Hungarian Meteorological Service (OMSZ), Budapest, Hungary

The Pannonian Basin Experiment (PannEx) is working towards becoming a new Regional Hydroclimate Project of the GEWEX Hydroclimatology Panel (GHP). The 3rd PannEx Workshop was held at the Facultatea de Geografie of the Universitatea Babeş-Bolyai with more than 60 participants from Romania, Hungary, Croatia, Serbia, Ukraine, Slovakia, Italy, France, Spain and The Netherlands. Dănuț Petrea, Dean of the Faculty of Geography, and Daniel David, Vice-Rector for Research, Competitiveness-Excellence, and Scientific Publications of Babeş-Bolyai University, opened the meeting. Mónika Lakatos, Chair of the PannEx International Planning Committee (IPC), Jan Polcher of Laboratoire de Météorologie Dynamique (CNRS), and Joan Cuxart of the University of the Balearic Islands, the latter representing GEWEX, also provided opening remarks.

The goal of PannEx is to enhance Earth science in the Pannonian Basin and contribute to the overall objective of the scientific community to improve the understanding of the climate system, its predictability and its effect on human activities. The workshop had five sessions with targeted scientific discussions led by the authors of the White Book, which lays out the structure and plans for PannEx.

Agricultural Response to Climate Change and Weather Extremes

Links between climate change and climate variability and crop production in Europe, and the impacts of crops and activities on crop health and yield, were examined using data from field experiments held in Hungary and Croatia. The extension of existing field campaigns and the setup of new field agrometeorological observations were recommended, as they are needed to increase our understanding of climate extremes on crop growth, yield amount and quality.

Extreme Weather and Climate Events as a Risk to Sustainable Development

Julia Keller of the World Weather Research Programme (WWRP) gave an overview of the program's research activities and discussed synoptic conditions for cold waves and cold spells in Romania, and the impacts of climate variability on forest growth. A suggestion was given to consider various emerging subseasonal and seasonal forecast products available for the countries in the Pannonian Basin.

Water for a Secure Society in Changing Climate Conditions

A review of water balance studies confirms that there is no uniform method in the modeling of the water balance to study the water cycle, which makes intercomparisons between models difficult. Formulas recently used for estimation of the components of the water balance sometimes contain coefficients that were developed under different climate conditions. One of the important issues raised in this session concerned the many diverse approaches in estimating evaporation in different countries and in different research fields. A common harmonization effort is therefore necessary.

Monitoring and Estimation of Climate Change for Extreme Weather Events

The results of the European Commission 7th Framework Programme (FP7) eartH2Observe Project were presented. Activities on drought monitoring in Slovakia; regional climate modeling in Croatia and Hungary; and emerging rapid prototyping software products related to Earth observations in Romania were discussed. Also, climate characteristics over the Danube and Pannonian Basins and Ukraine were explored, and results of the urban climate observational targeted activities in Budapest were presented to the participants.

Impact and Vulnerability Assessments of Climate Change and Extreme Weather Events on Different Sectors

Hydrological processes over small watersheds in Romania and advanced hydrological prognostic systems developed in Serbia were discussed. Other sectors tackled in this session included extensive boundary layer observations in Hungary, a project in Croatia that links boundary layer observations with the observed effects of climate change on wine production, evaluation of the low-level jets over the Pannonian Basin as simulated by the European Centre for Medium-range Weather Forecasts (ECMWF) prognostic system, and common meteorological and carbon dioxide observations in the town of Cluj-Napoca.

Future Actions

The first draft of the PannEx White Book was presented at the GHP meeting held in Gif sur Yvette, France in October 2016. The PannEx IPC have incorporated comments received from the GHP and will send the revised version to the PannEx mailing list for comments i=n May. After the White Book is finalized, the PannEx Science and Implementation Plan will be distributed for comments.

IPC members Mónika Lakatos and Tamás Weidinger will explore the possibility of organizing the next PannEx workshop in parallel with the European Meteorological Society Conference in Budapest in September 2018. In the meantime, the next IPC meeting on the Science and Implementation Plan will be coordinated by Vladimir Djurdjevic and held in September 2017 at the University of Belgrade.

Discussions concerning funding options, a logo for the initiative, and community growth resulted in concrete suggestions that will be explored in the following months. Workshop presentations and posters are available at: *https://sites.google.com/site/projectpannex/workshops/pannex2017presentations*.

Workshop on Addressing the Challenge of Compound Events

ETH Zurich, Switzerland
19–21 April 2017

Jakob Zscheischler[1], Seth Westra[2], Bart van den Hurk[3], Philip Ward[4], Andy Pitman[5] and Sonia I. Seneviratne[1]

[1]Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland; [2]University of Adelaide, Adelaide, Australia; [3]KNMI, De Bilt, The Netherlands; [4]Vrije Universiteit Amsterdam, The Netherlands; [5]University of New South Wales, Australia

Hazards such as floods, wildfires, heat waves and droughts often result from a combination of interacting physical processes that take place across a wide range of spatial and temporal scales. The combination of physical processes leading to an impact is referred to as a "compound event." In a recent workshop at ETH Zurich, more than 30 scientists from three continents and 11 different countries, including 11 early career scientists, discussed the current understanding of compound events, and how to move forward. Compound events in the context of climate change have been introduced to the broader climate science community by the Special Report on Climate Extremes (SREX) of the Intergovernmental Panel on Climate Change (IPCC) as: "(1) two or more extreme events occurring simultaneously or successively; (2) combinations of extreme events with underlying conditions that amplify the impact of the events; or (3) combinations of events that are not themselves extremes but lead to an extreme event or impact when combined. The contributing events can be of similar (clustered multiple events) or different type(s)" (Seneviratne et al., 2012). More recently, Leonard et al. (2014) suggested a more confined definition focusing on impacts and statistical dependence between the drivers: "A compound event is an extreme impact that depends on multiple statistically dependent variables or events." Intense discussions about how to define compound events were a common theme across all sessions of the workshop. This question is more than a matter of definition: it delineates very much the way to approach, study and predict compound events.

The Challenge

Compound events have been identified as an important challenge by the World Climate Research Programme (WCRP) Grand Challenge on Weather and Climate Extremes (*https://www.wcrp-climate.org/grand-challenges/gc-extreme-events*), which highlights their relevance to climate science. A better understanding of the nature of compound events should lead to better understanding and improved predictions of extreme impacts with direct benefits to society. Because of their complex nature, compound events require climate scientists, impact modelers and social scientists to work closely together to understand them. The insight that impacts rarely depend upon only one driver may lead to novel ways of examining climate model output if the goal is to simulate those extreme events that are likely to have the largest impacts. In this context, working together should enable the community to provide valuable insights on problems such as identifying those (combinations of) climatic drivers that lead to the largest impacts. In addition, the robust estimation of probabilities of co-occurring extremes, such as storm surge and precipitation (Wahl et al., 2015) or droughts and heat waves (Mazdiyasni and AghaKouchak, 2015), requires well-calibrated models or the usage of novel statistical tools from the active area of multivariate extreme value theory.

The workshop was organized in sessions corresponding to the four themes of the WCRP Grand Challenge on Extremes: Document, Understand, Simulate and Attribute. Each session was opened by a keynote talk, which provided an overview of the current state-of-the-art knowledge and presented major questions related to compound events and the respective theme. To keep the workshop highly interactive, participants presented recent results and research questions in short pitches. Furthermore, Mentimeter (http://*www.mentimeter.com*) was used for polls throughout the workshop to obtain an instant picture about the participants' thoughts. For instance, the question "What is a compound event to you?" was asked in the opening session (see figure on the left) and again at the end of the workshop, demonstrating how the importance shifted from the word "extreme" to "multivariate" over the course of the workshop.

Word cloud created from the responses of participants to the question, "What is a compound event to you?" This was done at the beginning of the workshop.

Document

In this session, the participants discussed questions related to data availability such as: (i) which climate variables need to be assessed jointly in order to characterize the relevant class of a compound event? (ii) How much is currently known about the dependence between these variables? and (iii) Are the observations sufficient to underpin the assessment of their dependencies in the historical climate and potential trends in their occurrence and/or dependence? The multivariate nature of compound events demands much longer time series to reach equally robust statistics as compared to the univariate case. Furthermore, to identify the most relevant climatic drivers, compound events require information on some type of impact such as flood depth, economic damage or lives lost. Impact data are, however, often highly heterogeneous and rarely centrally recorded. Hence, even identifying which data exist can be a challenge (data discoverability). To overcome these difficulties, the idea of a meta-database of available data sets from the different communities was discussed.

Understand

Understanding compound events is the first step towards a better simulation and prediction of potentially extreme impacts. In this session, the participants discussed questions such as: What drives compound events? How do drivers interact? How do drivers generate impacts? And what is the dependence between drivers? Important points raised in the discussion included the idea that in order to rank events (e.g., for computing return periods or other relevant statistics), there is a need to map multivariate drivers onto a univariate measure. This will generally be some type of potential or realized impact. To detect dependences in the drivers, multivariate extreme value theory might be necessary because the dependence in the tails may be different from the dependence for the remainder of the distribution, leading to particularly devastating impacts (e.g., a combination of extreme storm surge and extreme precipitation, Wahl et al., 2015). It was also emphasized that human decision can play a key role in alleviating or aggravating the impacts of compound events, and methods are required to capture the behavior of decision-makers, such as agent-based modeling approaches. The session also discussed the idea that very rare events cannot easily be characterized by their return time, as this is a quantity that is hard to quantify. Storyline approaches and "black swan" thinking need to enter the arena, giving room for experience with real world events. Nevertheless, for assessing the risk from compound events, we need to examine compound events of all sizes, not only the "black swans."

Simulate

The Simulate session was dedicated to questions related to the simulation of compound events such as: Are models able to reliably simulate the dependence between climate variables and how they might change in a future climate? What methods are available to evaluate the capacity of models to simulate an appropriate level of dependence between variables? What is the modeling capability to model the impacts of the variable dependence adequately? Acknowledging the multivariate nature of many high-impact events will affect our views on how to use and evaluate models. Models play a major role in the understanding of compound events, as data are often scarce. However, if dependences are misrepresented in models, compound events will also likely be modeled unreliably, compromising risk assessments. Furthermore, new ideas are required to extend bias correction methods to the multivariate case and to explore the space of potential high-impact events, as currently the extent to which bias correction methods maintain key dependences in the climate system is largely unknown. This exploration could be done, for instance, with storylines; that is, by shifting past events in space or time in the model world and estimating potential impacts. In order to get to socioeconomic impacts, it is important to be able to simulate the effects of compound events at the local scale. However, in many parts of the world, state-of-the-art local impact models are not available, and there is a need to nest local impact models within global physical models.

Trends and Attribute

The Trends and Attribute session dealt with the most uncertain parts of compound events research. Detecting trends requires long time series. Detecting trends in dependences

Participants of the workshop.

between variables requires even longer time series. The workshop discussed questions such as: to what extent are historical and/or projected changes in the identified compound events attributable to particular causes? Are the available modeling tools appropriate to enable attribution of compound events or classes of events? Do changes in external forcing change the physical mechanisms involved in compound events, leading to stronger or weaker connections? As an example, Wahl et al. (2015) detected an increase in the co-occurrence of extreme storm surge and precipitation events on U.S. coasts. Changes in co-occurrence can also occur if only one variable changes, such as increases in temperature, changes in water consumption and sea level rise.

Summary and Future Perspectives

Overall, the workshop demonstrated that advancing research on compound events requires a collective effort by different scientific communities, including not only climate modeling and impact modeling researchers, but also statisticians and disaster risk and resilience professionals. Progress will depend on the willingness to share knowledge between communities across disciplinary boundaries. During the workshop, all participants were pushed out of their comfort zone and were required to interact with scientists from various backgrounds. One main planned outcome will be a review paper reflecting on the topics discussed during the workshop. We also considered applying for status as a European Commission Cooperation in Science and Technology (COST) Action to initiate collaborations and to promote the dialog between disciplines on this exciting topic. COST Actions are bottom-up science and technology networks that facilitate the creation of a new scientific community by providing funding for meetings over a period of four years.

Acknowledgments

The workshop would not have been possible without generous funding from WCRP, the Australian Research Council Center of Excellence for Climate System Science (ARCCSS), ETH Zürich, the Vrije Universiteit Amsterdam and The Netherlands Organization for Scientific Research. The funding was primarily used to invite promising Early Career Scientists working on compound events to the workshop.

Leonard, M., S. Westra, A. Phatak, M. Lambert, Bart V. D. Hurk, K. Mcinnes, J. Risbey, S. Schuster, D. Jakob and M. Stafford-Smith, 2014. A compound event framework for understanding extreme impacts. *WIREs Clim. Change*, 5, 113–128.

Mazdiyasni, O., and A. AghaKouchak, 2015. Substantial increase in concurrent droughts and heatwaves in the United States. *Proc. Natl. Acad. Sci. U.S.A.*, 112(37), 11484–11489.

Seneviratne, S. I., et al., 2012. Changes in climate extremes and their impacts on the natural physical environment. IPCC Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) report, pp. 109–230.

Wahl, T., S. Jain, J. Bender, S. D. Meyers and M. E. Luther, 2015. Increasing risk of compound flooding from storm surge and rainfall for major US cities. *Nat. Clim. Change* 5(12), 1093–1097.

GEWEX/WCRP Calendar

For the complete Calendar, see: http://www.gewex.org/events/

6–8 June 2017—Clouds, their Properties and their Climate Feedbacks–What have we learned in the satellite era?—New York, New York, USA

22–23 June 2017—13th GRDC Steering Committee Meeting—Koblenz, Germany

4–7 July 2017—10th HyMeX International Workshop—Barcelona, Spain

10–12 July 2017—Third Pole Science Summit–TPE-CSTP-HKT Joint Conference—Kunming, China

10–14 July 2017—International WCRP/IOC Conference on Regional Sea Level Changes and Coastal Impacts—New York, New York, USA

10–14 July 2017—Workshop on the Future of Cumulus Parameterization—Delft, The Netherlands

19–20 July 2017—1st International Surface Working Group Meeting—Monterey, California, USA

19–23 July 2017—5th WGNE Workshop on Systematic Errors in Weather and Climate Models—Montreal, Canada

20–24 August 2017—7th International Workshop on Catchment Hydrological Modeling and Data Assimilation (CAHMDA VI)—Xi'an, Shanxi, China

11–14 September 2017—5th iLEAPS Science Conference—Oxford, United Kingdom

18–20 September 2017—4th Satellite Soil Moisture Validation and Application Workshop and CCI Soil Moisture User Workshop—Vienna, Austria

18–22 September 2017—COSPAR 2017—Jeju, Republic of Korea

25–28 September 2017—CFMIP Meeting on Clouds, Precipitation, Circulation, and Climate Sensitivity—Tokyo, Japan

9–13 October 2017—32th Session of WGNE—Exeter, United Kingdom

16–18 October 2017—25th SPARC Scientific Steering Group Meeting—Seoul, Republic of Korea

17–19 October 2017—GHP-TPE Workshop—Kathmandu, Nepal

25–26 October 2017—7th GVAP Workshop—Leicester, United Kingdom

13–17 November 2017—5th International Conference on Reanalysis (ICR5)—Rome, Italy

GEWEX NEWS

Published by the International GEWEX Project Office

Peter J. van Oevelen, Director
Dawn P. Erlich, Editor
Shannon F. Macken, Assistant Editor

International GEWEX Project Office
c/o USRA
425 3rd Street SW, Suite 940
Washington, DC 20024 USA

Tel: 1-202-527-1827
E-mail: gewex@gewex.org
Website: http://www.gewex.org