14TH SWISS CLIMATE SUMMER SCHOOL – "EXTREME EVENTS AND CLIMATE"
AUGUST 23 – AUGUST 28, 2015, ASCONA, SWITZERLAND

Website

http://www.c2sm.ethz.ch/education/summer-school/summer-school-2015.html

Recommended reading Material

ftp://iacftp.ethz.ch/pub_read/bey/SCSS2015_ReadingMaterial_v21072015.zip

PROGRAM OVERVIEW

	Sunday 23.08	Monday 24.08	Tuesday 25.08	Wed. 26.08	Thurs. 27.08	Friday 28.08
Morning		S2 Methods & techniques KN2	Parallel workshops with coffee break	S4 Projections of extremes – KN8	Parallel workshops with coffee break	S4 Projections of extremes KN9
		Poster session & Coffee break		Poster session & Coffee break		Poster session & Coffee break
		S2 Methods & techniques KN3		WG meeting		S5 Towards a resilient future KN11
		Lunch	Lunch	Lunch & Excursion	Lunch	Lunch
Afternoon	Arrival, Welcome	S2 Methods & techniques KN4	S3 Physical processes KN6		S5 Towards a resilient future KN10	S5 Towards a resilient future KN12
	S1 Introduction KN1	Poster session & Coffee break	Poster session & Coffee break		Poster session & Coffee break	- Poster Award Ceremony - Closure - Refreshment
	Working Groups (WG) setting up	S3 Physical processes KN5	S3 Physical processes KN7		WG presentations	Departure
	- Poster installation - Aperitif	Laptop clinic WG meeting	WG meeting			
Evening	Dinner	Dinner	Dinner	Dinner	Dinner	

Sessions & Keynote Talks

Session 1: Introduction
- KN1: Neville Nicholls (Monash U.) – Climate change and extreme events

Session 2: Methods and techniques
- KN2: Francis Zwiers (U. Victoria) – Detection and attribution of long term change in extremes
- KN3: Peter Stott (U.K. Met Office) – Extreme event attribution: Towards the operational attribution of extremes
- KN4: Lisa Alexander (U. New South Wales) – Data issues in the analysis of climate extremes

Session 3: Physical processes involved in climate extremes
- KN5: Christoph Raible (U. Bern) – Large-scale modes of variability associated with climate extremes
- KN6: Sonia Seneviratne (ETH) – Feedbacks and climate extremes: The role of land processes and human management
- KN7: Olivia Martius (U. Bern) – Extremes from the weather and dynamics perspective

Session 4: Projections of extremes
- KN8: Erich Fischer (ETH) – Projections of extremes: A plethora of uncertainties or more robust than widely recognized?
- KN9: Hayley Fowler (Newcastle U.) – Climate projections at local and regional scales: recent developments in very-high resolution dynamical downscaling

Session 5: Towards a resilient future
- KN10: Maarten van Aalst (Red Cross / Red Crescent Climate Centre; Columbia U.) – Extreme events in disaster risk management
- KN11: Robert Wilby (Loughborough U.) – Smarter use of climate risk information for vulnerability assessment and adaptation planning
- KN12: Christof Appenzeller (MeteoSwiss) – Climate and weather services and climate extremes

Workshops

- WS1: Analysis and prediction of climate variability and extremes – Mark Liniger and Jonas Bhend (MeteoSwiss)
- WS2: Extremes scenarios for Switzerland – Sven Kotlarski and Jan Rajczak (ETH)
- WS3: Extremes and impacts: Design your own climate adaptation strategy - a practical application of open-source probabilistic damage modelling – David Bresch (SwissRe)
- WS4: Case studies of extreme events – Heini Wernli (ETH)

KEYNOTE SPEAKER ABSTRACTS

Session 1: Introduction

KN1: Neville Nicholls (Monash U.) – Climate change and extreme events

People have always been affected by climate and weather extremes. A changing climate will change the frequency and intensity of extremes as well as their impact. But the impact of, and public interest in, specific extremes has varied in the past, as society has changed. Such long-term variations in how people are affected by extremes is just one of the many factors that complicate the study of extremes and how they are changing. Even defining what we mean by a "climate or weather extreme" is challenging. Despite these challenges, climate scientists have documented how extremes have changed or may change in the future (and our confidence in these changes). The consensus statements on this documented in successive IPCC assessments of climate change illustrate how our understanding of climate change effects on extremes has improved and where further work is needed. Finally, adaptation to extremes will be an important strategy to help us cope with changes caused by global warming. So, are we adapting to extremes? What can we do to improve adaptation?

Recommended reading:

- Summary for Policymakers of Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., et al (eds.)]. A Special Report of Working Groups I and II of the *Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19.

Session 2: Methods and techniques

KN2: Francis Zwiers (U. Victoria) – Detection and attribution of long term change in extremes

Detection and attribution refers to a collection of methods that are used to determine whether that has been a significant change in climate, and to attribute changes to causes, hopefully in a quantifiable manner. Detection and attribution methods that are applied to changes in the climatological mean state are well established, and are the basis for statements such as the IPCC AR5 assessment that "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century". This methodology has been adapted to the analysis of extremes in a number of ways, some of which rely upon extreme value theory to various degrees of sophistication. This lecture will review the approaches that have been used, and in the course of doing so will describe the basics of optimal fingerprinting and several approaches to the analysis of extremes. Results obtained via these methods have provided a substantial part of the basis for the IPCC AR5 assessment of changes in temperature and precipitation extremes.

Recommended reading:

- Christidis, N., P.A. Stott, F.W. Zwiers, 2014: Fast track attribution assessments based on pre-computed estimates of changes in the odds of warm extremes. Climate Dynamics, doi:10.1007/s00382-014-2408-x.
- Sun, Y., X. Zhang, F.W. Zwiers, L. Song, H. Wan, T. Hu, H. Yin, G. Ren, 2014: Rapid increase in the risk of extreme summer heat in Eastern China. Nature Climate Change, doi:10.1038/NCLIMATE2410.
- Zhang, X., H. Wan, F.W. Zwiers, G.C. Hegerl, X. Min, 2013: Attributing intensification of precipitation extremes to human influence. Geophysical Research Letters, 40, 5252-5257, doi:10.1002/grl.51010.
- Hegerl, G.C., F.W. Zwiers, 2011: Use of models in detection and attribution of climate change, Wiley Interdisciplinary Reviews Climate Change, 2, 570-591, DOI:10.1002/wcc.121.
- Zwiers, F.W., X. Zhang, J. Feng, 2011: Anthropogenic influence on extreme daily temperatures at regional scales. Journal of Climate, 24, 881-892, doi:10.1175/2010JCLI3908.1

KN3: Peter Stott (U.K. Met Office) – Extreme event attribution: Towards the operational attribution of extremes

Extreme climate events occur in a particular place, by definition, infrequently. It is therefore challenging to detect systematic changes in their occurrence given the relatively shortness of observational records. However there is a clear interest from decision makers from a variety of different sectors in the extent to which recent damaging extreme events can be linked to human induced climate change or natural climate variability. As a result of such interest the science of event attribution has been developed which seeks to determine to what extent anthropogenic climate change has altered the probability or magnitude of particular events. A number of different methodological approaches have been developed. Their results require careful communication. Since studies can frame the attribution question in different ways they could lead to apparently contradictory conclusions even when results are actually consistent. While the science of event attribution has developed rapidly in recent years, geographical coverage of events is patchy and based on the interests and capabilities of individual research groups. The development of operational event attribution systems would allow a more timely and methodical production of attribution assessments than currently obtained on an ad-hoc basis. For event attribution assessments to be used appropriately, remaining scientific uncertainties need to be robustly assessed and clearly communicated. This requires the continuing development of methodologies to assess the reliability of event attribution results.

KN4: Lisa Alexander (U. New South Wales) – Data issues in the analysis of climate extremes

In situ observations have formed the foundations of climate research for several centuries. Changes and improvements in instrumentation and observing practice over time have enabled more accurate observations to be made but this has had the effect of introducing non-climatic "inhomogeneities" into timeseries. This has made long-term analysis of variability and trends in climate variables difficult. These inhomogeneities are especially important for the analysis of climate extremes, which are particularly sensitive to the quality and consistency of the record being analysed. In this presentation I will outline some of the major data issues and challenges that have hampered the analysis of climate extremes. Further I will present some of the statistical techniques that are commonly used to identify and adjust for these inhomogeneities and will discuss how to deal with the scaling issues that exist between point-based observations and climate model output of extremes.

Recommended reading:

- Alexander, L.V. and C. Tebaldi C. 2012. Climate and weather extremes: Observations, modelling and projections [in "The Future of the World's Climate"]. Elsevier Science, ISBN 978-0-12-386917-3
- Dunn RJH, Donat MG, Alexander LV. 2014. Investigating uncertainties in global gridded data sets of climate extremes. CLIMATE OF THE PAST, 10(6), 2171-2199
- Trewin B. 2010. Exposure, instrumentation, and observing practice effects on land temperature measurements. WILEY INTERDISCIPLINARY REVIEWS-CLIMATE CHANGE, 1(4), 490-506

Session 3: Physical processes involved in climate extremes

KN5: Christoph Raible (U. Bern) – Large-scale modes of variability associated with climate extremes

The climate system consists of a complex set of components that exchange energy, matter and momentum on a wide range of spatial and temporal scales. Due to this complexity and the chaotic nature of the system (Lorenz 1967), a complete understanding of the processes governing the general circulation has not yet been achieved. One way to shed further light in the understanding of such processes, in particular those associated to long-term climate variability, is to characterize the climate system by means of so-called modes of variability. These modes refer to physically meaningful teleconnection patterns, which connect distant and coherently varying regions with each other, and are often characterized by a time-varying index and an associated spatial pattern (Stephenson et al. 2003).

The lecture starts in a first part with a general definition of mode of variability. Then, some examples are presented, including the North Atlantic Oscillation (NAO) and El Niño Southern Oscillation (ENSO). Thereby, current discussions on the stability of the locations of the center of actions of such modes are presented (Raible et al. 2014). The second part of the lecture considers how modes of variability affect extreme events. Here, the focus is set on the North Atlantic region, discussing how the dominant modes of variability in the mid-latitudes are connected to storminess in Europe (e.g., Raible 2007; Pinto et al. 2014).

Recommended reading:

- Buehler, T., C. C. Raible, and T. F. Stocker, 2011: On the relation of extreme North Atlantic blocking frequencies, cold spells, and droughts in ERA-40 in winter, Tellus, 63, 212-222.
- Lorenz, E. N. 1967: The nature and theory of the general circulation of the atmosphere, Tech. rep., WMO-No. 218, TP 115, WMO, Geneva, Switzerland, 161pp.
- Pinto, J. G., Gómara, I., Masato, G., Dacre, H. F., Woollings, T. and Caballero, R. (2014) Large-scale dynamics associated with clustering of extratropical cyclones affecting Western Europe. Journal of Geophysical Research: Atmospheres, 119 (24). 13,704-13,719. ISSN 2169-8996 doi: 10.1002/2014JD022305.
- Raible, C. C., F. Lehner, J. F. Gonzalez-Rouco, and L. Fernandez-Donado, 2014: Changing correlation structures of the Northern Hemisphere atmospheric circulation from 1000 to 2100 AD, Climate of the Past, 10, 537-550. doi:10.5194/cp-10-537-2014.
- Raible, C. C., 2007: On the relation between extremes of midlatitude cyclones and the atmospheric circulation using ERA40, Geophys. Res. Lett., 34, L07703, DOI: 10.1029/2006GL029084.
- Stephenson, D. B., Wanner, H., Broennimann, S., and Luterbacher, J., 2003: The North Atlantic Oscillation, Climatic significance and environmental impact, Geophys. Monogr. Ser., 134, 37–50.

KN6: Sonia Seneviratne (ETH) – Feedbacks and climate extremes: The role of land processes and human management

Several climate extremes of high relevance in inhabited areas, such as droughts and heatwaves, are strongly affected by land processes. In particular, changes in water availability over land, either through changes in precipitation forcing, vegetation uptake or human water management, substantially affect hot temperatures over land. In addition, drought occurrence is itself linked to land-vegetation-climate feedbacks. This presentation will provide a review of the main processes affecting climate extremes at the land-vegetation-atmosphere nexus (e.g. Seneviratne et al. 2010, Mueller and Seneviratne 2012, Greve et al. 2014). Beside physically-based feedback processes, also the effects of human interventions, e.g. through agricultural management (e.g. Davin et al. 2014) or regional water use will be addressed.

Recommended reading:

- Davin, E.L., S.I. Seneviratne, P. Ciais, A. Olioso, and T. Wang, 2014: Preferential cooling of hot extremes from cropland albedo management. Proc. Natl Acad. Sci., 111(27), 9757-9761, doi:10.1073/pnas.1317323111

- Greve, P., B. Orlowsky, B. Mueller, J. Sheffield, M. Reichstein, and S.I. Seneviratne, 2014: Global assessment of trends in wetting and drying over land. Nature Geoscience, 7, 716-721, doi: 10.1038/NGEO2247.
- Mueller, B., and S.I. Seneviratne, 2012: Hot days induced by precipitation deficits at the global scale. Proc. Natl Acad. Sci., 109 (31), 12398-12403, doi: 10.1073/pnas.1204330109.
- Seneviratne, S.I., T. Corti, E.L. Davin, M. Hirschi, E.B. Jaeger, I. Lehner, B. Orlowsky, and A.J. Teuling, 2010: Investigating soil moisture-climate interactions in a changing climate: A review. Earth-Science Reviews, 99, 3-4, 125-161, doi:10.1016/j.earscirev.2010.02.004

KN7: Olivia Martius (U. Bern) – Extremes from the weather and dynamics perspective

Extreme weather events often have significant societal and economic impacts. Understanding the processes leading to extremes events is therefore of crucial importance to provide good forecasts of these events and to understand the changes in the magnitude and frequency of extreme events in a warmer climate. This presentation focuses on the role of weather systems such as different types of cyclones or anticyclones for the formation of extreme events.

The presentation is organized into three parts. First an overview of the dynamical processes responsible for formation of extreme weather events is given. Then the link between these processes and weather systems such as different types of cyclones and anticyclones is established. This entails a discussion of the role of warm conveyor and cold conveyor belts and different types of fronts. In the last part we ask the question what distinguishes weather systems that cause extreme events from regular weather systems, i.e. address the question why do some weather system result in extreme events and others not.

Recommended reading:

- Stephan Pfahl, Erica Madonna, Maxi Boettcher, Hanna Joos, and Heini Wernli, 2014: Warm Conveyor Belts in the ERA-Interim Dataset (1979–2010). Part II: Moisture Origin and Relevance for Precipitation. *J. Climate*, **27**, 27–40. doi: http://dx.doi.org/10.1175/JCLI-D-13-00223.1
- Charles A. Doswell III, Clemente Ramis, Romualdo Romero, and Sergio Alonso, 1998: A Diagnostic Study of Three Heavy Precipitation Episodes in the Western Mediterranean Region. *Wea. Forecasting*, **13**, 102–124.
- Paul J. Neiman, F. Martin Ralph, Benjamin J. Moore, Mimi Hughes, Kelly M. Mahoney, Jason M. Cordeira, and Michael D. Dettinger, 2013: The Landfall and Inland Penetration of a Flood-Producing Atmospheric River in Arizona. Part I: Observed Synoptic-Scale, Orographic, and Hydrometeorological Characteristics. *J. Hydrometeor*, **14**, 460–484. doi: http://dx.doi.org/10.1175/JHM-D-12-0101.1
- Gray, S. L., Martínez-Alvarado, O., Baker, L. H. and Clark, P. A. (2011), Conditional symmetric instability in sting-jet storms. Q.J.R. Meteorol. Soc., 137: 1482–1500. doi: 10.1002/qj.859

<u>SESSION 4: PROJECTIONS OF EXTREMES</u>

KN8: Erich Fischer (ETH) – Projections of extremes: A plethora of uncertainties or more robust than widely recognized?

Decision makers express a strong need for reliable information on changes in climatic extremes over the coming decades as a basis for adaptation strategies. However, projections at these time scales involve large uncertainties at local to regional scale as a result of internal variability, even if climate models improve rapidly. Understanding and quantifying the role of internal variability is vital to identify the limits of predictability – the irreducible uncertainty in multi-decadal projections – and the limits of model evaluation and bias correction.

I will show that despite large irreducible uncertainties at local scale, in an aggregated spatial probability perspective projections are remarkably consistent already for the coming decades. Furthermore, the models agree well on the forced signal of temperature and heavy precipitation extremes, the pattern of change in the absence of internal variability. I argue that it is vital to specify whether model agreement or robustness refers to the forced signal or for individual realization. Likewise, the level of confidence in projections of extremes, often given in assessment reports, depends on whether a statement applies to a single realization of the future, or to the forced signal.

Recommended reading:

- Hawkins, E. & Sutton, R. The potential to narrow uncertainty in regional climate predictions. Bull. Am. Meteorol. Soc. 90, 1095-1107 (2009).
- Deser, C., Knutti, R., Solomon, S. & Phillips, A. Communication of the role of natural variability in future North American climate. Nature Clim. Change 2, 775-779 (2012).
- Fischer, E.M., Beyerle, U. & Knutti, R. Robust spatially aggregated projections of climate extremes, Nature Climate Change, doi:10.1038/nclimate2051 (2013).

KN9: Hailey Fowler (Newcastle U.) – Climate projections at local and regional scales: recent developments in very-high resolution dynamical downscaling

The impacts of most extremes are typically felt at a local or regional scale; so regional studies of climate extremes are of the highest priority for most countries for assessing potential climate impacts. To examine potential changes to climate extremes, researchers have used 'downscaling' techniques, both statistical and dynamical, to address the scale mismatch between coarse resolution global climate model (GCM) output and the regional or local catchment scales required for climate change impact assessment. Comparison of different methods suggest that statistical and dynamical methods both have merit for different variables, seasons and climates and there is no, one, perfect solution. The talk will go on to explore the recent proliferation of dynamical downscaling – with the CORDEX multi-model ensembles – and how far this goes towards providing information relevant for impact studies. A proliferation of very high-resolution studies, now ongoing, using regional climate models may help to improve the simulation of high-impact events and the talk will explore recent developments in this area and what they tell us about the nature of results from coarser resolution climate models in terms of their robustness. The talk will end by exploring how these very high resolution climate model results can now be used to provide information motivated by the needs of policy makers and industry.

Recommended reading:

- Ban, N., Schmidli, J. & Schaer, C. Evaluation of the convection-resolving regional climate modeling approach in decade-long simulations. J. Geophys. Res. 119, 7889–7907 (2014).
- Fowler, H.J., Blenkinsop, S. and Tebaldi, C. 2007. Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling. International Journal of Climatology, 27(12), 1547-1578.
- Fowler, H.J. and Wilby, R.L. 2007. Beyond the downscaling comparison study. International Journal of Climatology, 27(12), 1543-1545.

- Kendon, E.J., Roberts, N.M., Fowler, H.J., Roberts, M.J., Chan, S.C. and Senior, C.A. 2014: Heavier summer downpours with climate change revealed by weather forecast resolution model. Nature Climate Change, 4, 570–576, doi:10.1038/nclimate2258.
- D. Maraun, F. Wetterhall, A.M. Ireson, R.E. Chandler, E.J. Kendon, M. Widmann, S. Brienen, H.W. Rust, T. Sauter, M. Themessl, V.K.C. Venema, K.P. Chun, C.M. Goodess, R.G. Jones, C. Onof, M. Vrac and I. Thiele-Eich: Precipitation Downscaling under climate change. Recent developments to bridge the gap between dynamical models and the end user, Rev. Geophys. 48, RG3003, DOI: 10.1029/2009RG000314, 2010
- Westra, S., Fowler, H.J., Evans, J.P., Alexander, L.V., Berg, P., Johnson, F., Kendon, E.J., Lenderink, G. and Roberts, N.M. 2014. Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52(3), 522–555 DOI: 10.1002/2014RG000464.

<u>SESSION 5: TOWARDS A RESILIENT FUTURE</u>

KN10: Maarten van Aalst (Red Crescent Climate Centre; Columbia U.) – Extreme events in disaster risk management

This lecture will discuss the use of information on extremes in disaster risk management. Starting with a discussion on the central concept of "risk", we will review several examples of past disasters, and assess our ability to anticipate trends in hazards, exposure and vulnerability.

We will then zoom in on the Red Cross Red Crescent, and discuss efforts to manage rising risk affect humanitarian work. This includes the concept of "Early Warning, Early Action", and the use of climate information across timescales. Particular examples include the West African monsoon season of 2008, and heatwaves in Europe.

Finally, the lecture will present some examples of how scientific information on risk can be communicated more effectively to target audiences. One example is "real-time attribution", in order to provide climate information about an extreme event at the right time, when the impacts are being felt and discussed in mainstream media, for instance by broadcast meteorologists on the evening news. Another example is the use of animations to stimulate discussion on climate change in communities in the Pacific Islands region. Finally, the use of "serious games" has helped link science to decisions, from local villages to international policy fora such as the UNFCCC and the White House (and if time allows, participants will be able to experience on of the climate risk games themselves).

KN11: Robert L. Wilby (Loughborough U.) – Smarter use of climate risk information for vulnerability assessment and adaptation planning

Climate model output has been used in impact assessments for about 40 years. Scenario-led methods raise awareness of risks posed by climate variability and change to the security of natural resources, performance of infrastructure, and health of ecosystems. However, it is less clear how such analyses translate into actionable information for adaptation. One explanation is that scenario-led methods typically yield very large uncertainty bounds in projected impacts at regional scales. Hence, there is growing interest in vulnerability-based frameworks and smarter ways of deploying climate model information in decision-making contexts.

This talk sets out contrasting perspectives on climate models and their utility with special reference to water sector applications. Using the Decision Centric (DC) version of the Statistical DownScaling Model (SDSM-DC) it is shown how synthetic climate change scenarios can be used for stress testing adaptation options. Three worked examples are presented. First, an analysis of precautionary allowances for flood risk management in the Boyne catchment, Ireland. Second, an evaluation of a relaxation agreement for allocating water in the physically and legally complex case of water diversions from the Upper Colorado River across the Continental Divide to cities and farms along Colorado's Front Range. Third, an appraisal of ecological flow requirements and smart water licensing is presented for the River Itchen, UK. The talk concludes by considering the wider implications of the proposed approach and points to some outstanding research questions.

Recommended reading:

- Brown, C. and Wilby, R.L. 2012. An alternate approach to assessing climate risks. Eos, 92, 401-403.
- Wilby, R.L., Dawson, C.W., Murphy, C., O'Connor, P. and Hawkins, E. 2014. The Statistical DownScaling Model – Decision Centric (SDSM-DC): Conceptual basis and applications. Climate Research, 61, 251-268.
- Wilby, R.L., Fenn, C.R., Wood, P.J., Timlett, R. and LeQuesne, T. 2011. Smart licensing and environmental flows: Modelling framework and sensitivity testing. Water Resources Research, 47, W12524.
- Yates, D., Miller, K.A., Wilby, R.L. and Kaatz, L. 2015. A decision-centric approach to climate adaptation options appraisal. Climate Risk Management, in press.

KN12: Christof Appenzeller (MeteoSwiss) – Climate and weather services and climate extremes.

Various economic sectors and society are vulnerable to weather and climate extremes such as storms, floods, droughts or heat waves. The World Meteorological Organization (WMO) reported more than 8000 weather and climate related disasters globally since 1970 that caused roughly 2 million loss of lives and economic damages of more than 2 trillion US dollars. Storms and floods accounted roughly for 80% of all these events. Similarly in Switzer-land, floods and landslides lead to economic damages summing up to 14 billion Swiss Francs during a comparable time period.

One of the core task of a National Weather and Climate Service is to prevent and reduce such impacts and related damages. This is achieved through several activities. The tasks of the weather services include detecting, monitoring and predicting such events and providing warnings to the public and various specific economic sectors. The tasks of the climate services include analyzing and projecting the occurrence of such events for planning and decision-making. As anthropogenic climate changes will continue, the projection task is particularly challenging since weather patterns will change and hence the chances of occurrence of certain weather and climate extremes will increase or decrease.

In this key lecture I will provide some background information how the relevant weather and climate services are organized at MeteoSwiss, what the key challenges are and how recent und future scientific developments can help to improve the services. A particular focus will be given to probabilistic ensemble forecasts, that can be used in early warning system, both in the medium and long range forecast context.

WORKSHOP DESCRIPTION

WS1: Analysis and prediction of climate variability and extremes – Mark Liniger and Jonas Bhend (MeteoSwiss)

Managing the risks of climate variability and longer-term climatic changes have received increased attention over the recent years in both the private and public sectors. For an effective adaptation planing, accurate information on climatic variability may serve as a basis for decision-making: for instance in the agricultural, health, energy or financial sector this additional information is of high relevance on time-scales of several weeks up to seasons. Recent developments in climate monitoring and research have produced substantial improvement in understanding and predicting climatic fluctuations on all time-scales. While seasonal climate forecasting has nowadays become an established technique at several weather forecasting centres including the European centre for medium-range weather forecast (ECMWF), decadal predictions are still a relatively new field of research that bridge the challenging gap between seasonal forecasts and climate change projections.

Seasonal and decadal predictions are based on the idea that boundary conditions of the climate system have a much longer memory than the atmosphere and hence are at least partly predictable some months and years ahead. Some of these processes have only local effects on the climate, while others can have almost global impact. For example, one of the most important source of seasonal predictability, the coupled ocean-atmosphere phenomenon of ENSO (El Niño / Southern Oscillation), is characterized by anomalies of the surface temperatures of the tropical Pacific, but its effects can be detected at many parts of the globe. Consequently, a correct prediction of ENSO can provide information on the expected state of the climate in very distant places.

In this workshop we will analyze global teleconnection patterns of important variability modes in the climate system using observation-based datasets. In particular, the impact of ENSO on the tropical and extratropical regions shall be investigated. In the second part we will focus on the predictive skill of state-of-the-art forecasting systems and climate model projections. As a main tool for these evaluations, the KNMI Climate Explorer will be used (see link below). The KNMI Climate Explorer is a powerful web tool that allows the user to statistically evaluate several dozens of different climate datasets in interactive mode.

Recommended reading:

- Troccoli, A., Seasonal Climate Forecasting, Meteorological Applications, 17, 251-268 (2010), doi: 10.1002/met.184.
- Goddard, L., S. J. Mason, S. E. Zebiak, C. F. Ropelewski, R. Basher and M. A. Cane, Current Approaches to seasonal-to-interannual climate predictions, International Journal of Climatology, 21, 1111-1152 (2001), doi: 10.1002/joc.636.
- Brönnimann, S., Impact of El Niño-Southern Oscillation on European climate, Rev. Geophys., 45, RG3003 (2007), doi: 10.1029/2006RG000199.
- Wilks, D.S., Statistical Methods in the Atmospheric Sciences, Third Edition, Elsevier, 704pp, 2011. Chapter 8: Forecast verification.

Useful links:

- KNMI Climate Explorer http://climexp.knmi.nl/
- European Centre for Medium-Range Weather Forecasts (ECMWF) http://www.ecmwf.int/
- The US Climate Prediction Center http://www.cpc.ncep.noaa.gov/
- International Research Institute for Climate Prediction http://iri.ldeo.columbia.edu/
- Federal Office of Meteorology and Climatology (MeteoSwiss) http://www.meteoswiss.ch

WS2: Extremes scenarios for Switzerland – Sven Kotlarski and Jan Rajczak (ETH Zurich)

This workshop will provide an introduction to the assessment of future changes in extreme temperature and precipitation conditions on regional scales based on regional climate model (RCM) output. Especially when considering localized extreme events in topographically structured terrain the latter provide an added value with respect to global climate models (GCMs). During the workshop several members of the recent EURO-CORDEX RCM ensemble (www.euro-cordex.net) will be analyzed with respect to projected changes of daily extreme indices over Switzerland and the inherent projection uncertainties. The model ensemble (partly) samples the influence of the greenhouse gas emission scenario, the driving GCM and the applied RCM. Prior to the analysis, a brief introduction into the technique of regional climate modelling and the related data formats will be presented. Hands-on exercises will be carried out using the CDO Climate Data Operators and the R statistical software package.

Recommended reading:

- Frei C, Schöll R, Fukutome S, Schmidli J, Vidale PL (2006) Future change of precipitation extremes in Europe: Intercomparison of scenarios from regional climate models. Journal of Geophysical Research, 111, D06105.
- Kotlarski S, Keuler K, Christensen OB, Colette A, Déqué M, Gobiet A, Goergen K, Jacob D, Lüthi D, van Meijgaard E, Nikulin G, Schär C, Teichmann C, Vautard R, Warrach-Sagi K, Wulfmeyer V (2014) Regional climate modelling on European scales: A joint standard evaluation of the EURO-CORDEX RCM ensemble. Geoscientific Model Development, 7, 1297-1333.
- Rajczak J, Pall P, Schär C (2013) Projections of extreme precipitation events in regional climate simulations for Europe and the Alpine Region. Journal of Geophysical Research, 118, 3610-3626.
- Torma C, Giorgi F, Coppola E (2015) Added value of regional climate modeling over areas characterized by complex terrain-Precipitation over the Alps. Journal of Geophysical Research, in press, doi: 10.1002/2014JD022781.

WS3: Extremes and impacts: Design your own climate adaptation strategy - a practical application of open-source probabilistic damage modelling – David Bresch (SwissRe)

Climate adaptation is an urgent priority for the custodians of national and local economies, such as finance ministers and mayors. Such decision makers ask: 1) What is the potential climate related damage to our economies and societies over the coming decades? 2) How much of that damage can we avert, with what measures? 3) What investment will be required to fund those measures - and will the benefits of that investment outweigh the costs?

Put yourself in the shoes of a local decision maker and gain hands-on experience with the economics of climate adaptation (ECA) methodology as implemented in the open-source climada tool (https://github.com/davidnbresch/climada). Working in small teams, this will enable you to understand the effect of weather and climate on an economy - and to identify actions to minimise that impact at lowest cost. It demonstrates how to integrate adaptation with economic development and sustainable growth.

Using state-of-the-art probabilistic modelling, we will estimate the expected economic damage as a measure of risk today, the incremental increase from economic growth and the further incremental increase due to climate change. We will then build a portfolio of adaptation measures, assessing the damage aversion potential and cost-benefit ratio for each measure. The resulting adaptation cost curve will help us compare results at the end of the workshop - which will conclude with a critique of the methodology.

Recommended reading:

- The climate resilience story: http://media.swissre.com/documents/sigma1_2014_en.pdf#page=17
- Short introduction to the ECA methodology and global overview of case studies done so far: http://media.swissre.com/documents/Economics_of_Climate_Adaptation_focus_infrastructure.pdf
- Reference: the climada manual (and access to the full tool, ready to use with MATLAB or Octave): https://github.com/davidnbresch/climada/blob/master/docs/climada_manual.pdf

WS4: Case studies of extreme events – Heini Wernli (ETH)

Extreme events typically involve complex dynamics (see also KN7 by O. Martius) and understanding the relevant processes and their interaction often comes from detailed case studies of individual events. Such an approach, using a combination of theoretical and diagnostic concepts (e.g., potential vorticity charts, identification of cyclones and fronts, air parcel trajectories), offers the possibility to learn about how nature creates extreme events and how they differ from "normal weather". However, one has to keep in mind, that single cases are often not representative for an entire category of extremes; for instance, studying the dynamics of a storm like "Kyrill" (2007) does not lead to results that are necessarily valid for other high-impact cyclones.

In this workshop, a selection of recent extreme events will be investigated, by studying pre-fabricated meteorological charts and output from special diagnostics. The selection of the cases will include the Alpine flood in August 2005 (Hohenegger et al. 2008), the wet snowfall event in November 2005 (Frick and Wernli 2012), and a windstorm hitting the coast of Portugal in January 2013 (Liberato 2014). The goals of the workshop will be to (i) understand the use of the different charts and diagnostics, (ii) create a "story" of the dynamics of the event, and (iii) discuss the differences of the relevant processes involved in the different types of extreme events.

Recommended reading:

- Frick, C., and H. Wernli, 2012. A case study of high-impact wet snowfall in Northwest Germany (25-27 November 2005): Observations, dynamics and forecast performance. Wea. Forecasting, 27, 1217-1234.
- Hohenegger, C., A. Walser, W. Langhans, and C. Schär, 2008. Cloud-resolving ensemble simulations of the August 2005 Alpine flood. Q. J. R. Meteorol. Soc., 134, 889–904.
- Liberato, M. L. R., 2014. The 19 January 2013 windstorm over the North Atlantic: large-scale dynamics and impacts on Iberia. Weather and Climate Extremes, http://dx.doi.org/10.1016/j.wace.2014.06.002i