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Uhrzeit	Thema	Vortragende/ Sitzungsleitung
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17:15	**AK Verwaltung** bis 18:15 Uhr	
19:30	**Gemeinsames Abendessen / Conference Dinner** im Gasthaus Marquardtei (**kleine Menü-Auswahlliste an der Rezeption, bitte dort unbedingt eintragen**)	

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12:30	**Ende der Tagung**	
14:00 / 14:30	**Mit dem Stocherkahn über den Neckar** Tübingen; Fußweg zur Ablegestelle beim Casino ca. 15 Minuten; Stocherkahnfahrt ca. 1 Stunde (**Anmeldung an der Rezeption erforderlich; die Teilnehmerzahl ist leider begrenzt!)**	

Vortragsabstracts

Stadt und Land – Modell und Messung 1

Simulation zweier sommerlicher Perioden in Augsburg mit dem LES-Modell PALM-4U zur Analyse städtischer Cold- und Hot-Spots

Annette Straub[1], Christoph Beck[1], Christoph Knote[2], David Jean du Preez[2], Christopher Holst[3], Andreas Philipp[1]

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[2] Model-based Environmental Exposure Science, Medizinische Fakultät, Universität Augsburg, Augsburg, Deutschland

[3] IMK-IFU, KIT-Campus Alpin

Die Probleme, die mit Hitzebelastung insbesondere in Städten einhergehen, sind allgemein bekannt. Um die raumzeitliche Temperaturverteilung im urbanem Raum zu fokussieren, wird das mikroklimatische Modell PALM-4U für die Simulation von zwei Sommertagen im Stadtgebiet von Augsburg angewendet. Modelliert werden ein Hitzetag mit autochtoner Wetterlage sowie ein Referenztag, der sich durch eine Sommersituation mit gemäßigteren Temperaturen und stärkerer Durchmischung auszeichnet. Für diese beiden Tage wird PALM-4U mit Hilfe stationärer Messungen sowie Vertikalprofilen aus Messflügen mit unbemannten Luftfahrtsystemen evaluiert. In einer dritten Simulation werden verschiedene Maßnahmen zur Minderung der thermischen Belastung, beispielsweise Dachbegrünung und zusätzliche Straßenbäume, integriert. Deren Effekte werden unter Annahme der meteorologischen Randbedingungen des Hitzetages untersucht. Alle Simulationen decken einen Großteil des Stadtgebiets (8800m x 6400m) sowie einen Zeitraum von 36 bzw. 42 Stunden ab und werden mit meteorologischen Randbedingungen aus COSMO-D2 dynamisch angetrieben.

Des Weiteren werden Untersuchungen zum Einfluss der meteorologischen Randbedingungen aus dem mesoskaligen Modell auf die Ergebnisse von PALM-4U durchgeführt. Hierzu wird ein zweiter dynamischer Antrieb basierend auf einer WRF-Simulation erstellt. Dieser wird genutzt, um die Simulation für den Hitzetag bei ansonsten unverändertem Setup zu wiederholen und Vergleiche mit dem ersten, COSMO-D2-basierten Lauf durchzuführen.

Schließlich wird die räumliche Verteilung von Hotspots und Coolspots sowie deren zeitliche Dynamik charakterisiert und Einflussfaktoren betrachtet.

Die Arbeiten fanden im Rahmen der Fördermaßnahme “Stadtklima im Wandel” - Urban Climate Under Change [UC]² im Teilprojekt “Strategien zur Minderung kritischer stadtklimatischer Belastungssituationen in Augsburg” (MIKA) statt.

A systematic approach for an urban meteorological sensor testing and placement to study urban air temperature variability in Kassel

Shakir Ahmed, Britta Jänicke

The impacts of climate change are already evident around the world and especially in urban areas. The increasing intensity and frequency of events such as urban heat islands, local and regional heat waves along with high urbanization trends are bringing growing challenges for urban and environmental planning. Ground-based observation station networks remain key data sources for local climate impact analyses and for cross validations of remote sensing data, urban climate models and quantitative crowd-sourced data of urban climate parameters. Setting up a sound urban climate observation network is challenging due to specific sensor requirements such as accuracy, compactness and independently power supply and appropriate sensor placement regarding the different local climate zones (LCZ) and topographic factors to capture the temperature variability with limited number of stations.

The objective of this study is to (1) provide an overview and an evaluation of compact All-In-One (AIO) and low-cost weather stations usable in urban environments and (2) to develop a systematic and statistically driven approach for selecting sites for sensor placement by using the city of Kassel, Germany as a test-bed. First results indicate that various sensors are available, but a high accuracy of below 0.5°C and low power consumption are the most critically aspects, which results in three AIO and five low-cost sensors to be tested and evaluated in near future. For the systematic sensor placement, different background mapped data and statistically approaches were tested and compared. The research outcome will help other studies to set-up reliable and profound urban climate observation networks.

UnLuBW - Pollutant monitoring through technological development of UAS applications

Kjell zum Berge, Moritz Mauz, Franziska Geske, Christoph Schlettig, Andreas Platis

In recent years, there has been a growing emphasis on air quality in urban areas, attracting attention from society, media, and politics. Research has identified particulate matter and nitrogen oxides, primarily originating from private motor vehicles, energy production, and heating, as detrimental to health. To safeguard the well-being and quality of life for the population, various measures based on EU directives, such as driving restrictions, speed limits, and designated green areas, have been implemented. However, the validity of assessing pollution levels based on limited measurements from a few stations, particularly when justifying stringent measures, has been heavily debated in public and scientific circles (Hooftman et al., 2018; BMU, 2021).

On the other hand, establishing a comprehensive network of sensors throughout a city is costly, requires substantial maintenance, and creates competition for utilization of public spaces. To enhance public acceptance of air pollution control measures and improve the reliability of local measurements for traffic policy decisions, a collaborative effort between UnLuBW (funded by the Federal Ministry for Digital and Transport) and selected municipalities aims to develop a concept. This concept will enable flexible and meaningful measurement of particulate matter and nitrogen oxides using small and affordable unmanned aircraft systems (UAS) (Lambey and Prasad, 2021). The utilization of UAS in studying pollutant dispersion is also addressed in a recent VDI guideline (Foken and Bange, 2020).

The proposed approach involves deploying small UAS during measurement campaigns conducted before and after initiatives aimed at reducing particulate matter and nitrogen oxide emissions. These unmanned aircraft systems will simultaneously measure particles, various gases, and meteorological data at multiple locations within selected municipalities. The collected data will be compared and evaluated to assess the effectiveness of the implemented measures.

Stadt und Land – Modell und Messung 2

Quantifying Natural CO_2 Emissions with Low-Cost Sensor Network

Yann Büchau, Jens Bange

Quantifying the entrainment of greenhouse gases from the subsurface into the lower atmosphere is a common requirement in many fields such as agriculture, biosphere-atmosphere interaction research, oil and gas mining, and greenhouse gas quantification efforts in general. Particularly at carbon capture and sequestration (CCS) sites, proper monitoring of leaked CO_2 is required for integrity assessment. Gas monitoring equipment such as accumulation chambers and eddy covariance (EC) stations are usually very expensive, which limits the spatial resolution of the observations. Networks of low-cost sensors can help to monitor sites with very heterogeneous gas emissions or large spatial extent. In this talk, we present our autarkic wireless low-cost CO_2 sensor network deployed at the Starzach site - a site near Tübingen with naturally occurring CO_2 emissions of non-volcanic magmatic origin, which is a suitable analogue for a leaking CCS site. Results and experiences from the continuous operation of such a network will be presented.

Klima- und Gesundheitseffekte unterschiedlicher urbaner Waldstrukturen

Jonathan Simon, Joachim Rathmann, Bhargavi Mahesh, Yekta Said Can, Max Stocker, Elisabeth André, Andreas Philipp, Christoph Beck

Urbane Wälder sind eine Ressource für die menschliche Gesundheit. Sie verbessern die Luftqualität und senken die Lufttemperatur. Darüber hinaus erbringen sie mehrere wichtige Ökosystemleistungen (CO2-Bindung, Lebensraum, Erosionsschutz, Wasserfilterung, Erholung u.v.m.). Jedoch unterscheiden sich urbane Wälder beispielsweise in der Zusammensetzung der Baumarten, der Altersstruktur, den Lichtverhältnissen, sowie der Artenvielfalt. In der Bewertung unterschiedlicher Ökosystemleistungen können diese physischen Waldmerkmale nicht unabhängig von der subjektiven menschlichen Wahrnehmung betrachtet werden.

Hauptziel des klimatologischen Teils der vorliegenden Studie ist die Klärung der Frage, inwieweit unterschiedliche urbane/peri-urbane Wald- und Offenlandstrukturen unterschiedliche lokal- und humanbioklimatologische Eigenschaften besitzen. Ein weiteres Ziel der Studie ist die Erfassung, Digitalisierung, Aufbereitung, Modellierung und Auswertung von Daten zu humanphysiologischen Effekten und subjektiver Wahrnehmung, die im Rahmen von Feldexperimenten und Befragungen in ausgewählten Untersuchungsregionen innerhalb des Augsburger Stadtgebietes (Wohngebiet, städtischer Park) und des Augsburger Stadtwaldes (Mischwald, Buchenwald, Kiefernwald, Heidefläche) gewonnen werden. Das Lokalklima der Untersuchungsgebiete wird mit dem Mikroklimamodell ENVI-met modelliert und mit Feldmessungen von Klimavariablen wie Lufttemperatur und relativer Luftfeuchtigkeit validiert. Ein Messnetz mit HOBO MX2301A Loggern wird errichtet, um langfristige und saisonale Klimaeffekte in den Untersuchungsgebieten zu erfassen. Daten zu humanphysiologischen Effekten werden in „thermal walks“ entlang vordefinierter Routen durch die Untersuchungsgebiete gesammelt, wobei die Teilnehmer mit tragbaren Sensoren ausgestattet werden, die physiologische Daten wie die Herzaktivität erfassen. Mit Hilfe von Fragebögen werden soziodemografische Daten und die subjektiven Wahrnehmungen der Teilnehmer (thermische und visuelle Empfindungen) während der Spaziergänge erfasst. Subjektive thermische Empfindungen werden mit objektiv abgeleiteten thermischen Indizes verglichen.

Messungen bioklimatischer Parameter, physiologischer Reaktionen des Menschen und die Erfassung des subjektiven Wohlbefindens sowie der subjektiven Wahrnehmung von Umweltvariablen ermöglichen eine umfassende Analyse positiver gesundheitsrelevanter Mensch-Umwelt-Beziehungen in verschiedenen urbanen Waldstrukturen.

Impacts of extreme droughts on pine forest stands in southwestern Germany

Edurne Martinez del Castillo, Max Torbenson, Frederick Reinig, Oliver Konter,
Emanuele Ziaco, Jan Esper

Droughts have progressively increased over the last decades and have become more frequent and intense, affecting forest in large parts of Europe. The unique combination of factors during drought events is changing the dynamics of forests by affecting growth dynamics and increasing the mortality rates in forests. The tree's ability to resist and recover from droughts is determined by numerous intrinsic factors (e.g. genetic characteristics, life stage, and life history) and physiological mechanisms, resulting in highly individualistic tree responses. Because this key information is often overlooked from an ecological perspective in studies focused on population response, we investigated how a major drought event affected forests at the individual tree level. Twenty Scots pine stands in SW Germany were sampled and used to test the individual tree responses to the 1976 drought, one of the strongest such event in Central Europe in the last century. Trees showing a prolonged post-1976 growth reduction were considered suppressed and compared with neighboring, "control" trees. We found varying proportions of suppressed trees within the forest stands, independent of drought intensity and mean climate conditions. In most cases, the growth reductions lasted more than a decade indicating extended drought legacy effects. The divergent growth trajectories between suppressed and control trees yielded contrasting results in the resilience analysis. Temporarily affected trees showed 50% reduced capacity to return to their original state (relative resilience) as well as a drop in resistance over 4 years after the disturbances as indicated by lower recovery rates and longer recovery periods. Correlations between control and suppressed tree chronologies and climate data revealed temporally varying results and distinct differences before and after the 1976 drought. Particularly the suppressed trees indicate an increased sensitivity to maximum temperatures and summer droughts. The 1976 drought was a tipping-point for pine forests from SW Germany as it preceded unreversible changes in tree's growth dynamics, especially in temporarily suppressed individuals but also in the entire pine population. Detailed information on the individual responses to drought stress is crucial for understanding future carbon-assimilation patterns, realistic climate constrains, and detailed drought legacy effects, especially in areas of increasing drought occurrence.

Nebel – Klimatologie

A regime-based analysis of fog and low stratus life cycle processes across central Europe

Eva Pauli, Jan Cermak, Hendrik Andersen, Julia Fuchs

This contribution quantifies the impact of environmental conditions on fog and low stratus (FLS) life cycle patterns and processes with respect to geographic FLS regimes. Knowledge on patterns and processes of the FLS life cycle, in particular its timing of formation and dissipation, is important for traffic security and solar power prediction. However, quantitative, satellite-based analyses of the influence of environmental conditions on the FLS life cycle, especially in relation to different geographic FLS regimes, are lacking:

In this study, satellite-based FLS life cycle and reanalysis data sets are combined in a clustering approach to detect FLS life cycle regimes over central Europe. In addition, FLS life cycle patterns and processes are analyzed in regional regimes using explainable artificial intelligence (xAI) methods. In this set up, multivariate influences of meteorological and land-surface based conditions are analyzed, with a particular focus on the role of aerosols, quantified by satellite measurements of aerosol optical depth (AOD).

The FLS life cycle regimes identified by the clustering algorithm show distinct differences in FLS occurrence, life cycle patterns and geographic extent. Results of the sensitivity analysis suggest that the influence of environmental drivers on FLS life cycle processes strongly depends on the climatological characteristics of the FLS regimes considered. In a regional case study in the Po valley region, the sensitivity of FLS duration to changes in AOD indicates that a higher number of aerosols prolongs the duration of FLS events. The findings of this study further lead the way to a satellite-based classification of FLS types based on their formation and dissipation mechanisms and sensitivities to environmental conditions.

Machine learning based radiation fog nowcast with station data in Germany

Michaela Vorndran, Adrian Schütz, Jörg Bendix, Boris Thies

Nowcasting radiation fog remains a challenging and essential task due to its significant impact on traffic safety and economic activity. Current numerical weather prediction models face limitations in computational intensity and knowledge gaps regarding fog-influencing processes. Machine Learning (ML) models, particularly those utilizing the eXtreme Gradient Boosting (XGB) algorithm, present a promising alternative by leveraging their ability to learn directly from data, swiftly generate nowcasts, and handle non-linear relationships among fog variables. However, unlike recurrent neural networks, XGB does not inherently handle temporal data, which is crucial for understanding fog formation and dissipation. To address this limitation, our research proposes incorporating preprocessed temporal data into the model training process and applying a weighted moving average filter to regulate substantial fluctuations commonly observed in fog development. By employing an ML training and evaluation scheme specifically designed for time series data, we conducted an extensive bootstrapped analysis to compare the influence of different smoothing intensities and trend information timespans on the model's performance at three levels: overall performance, fog formation, and fog dissipation. We validated the performance against one benchmark and two baseline models. Significant performance improvements were observed for a station in Linden-Leihgestern (Germany). The initial F1 score of 0.75 (prior to smoothing and trend information incorporation) was enhanced to 0.82 after applying the smoothing technique and further increased to 0.88 when trend information was incorporated. The forecasting periods ranged from 60 to 240 minutes into the future. The newest results from this research will be presented at the AK Klima conference.

The study is funded by the DFG research project “FOG-ML FOrecasting radiation foG by combining station and satellite data using Machine Learning”.

Multiscale measurements of fog variability in the Coastal Chilean Atacama Desert

Juan Carlos Pastene[1,2], Alexander Sigmund[1,2], Camilo del Río[3], Pablo Osses[3]

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[3] Instituto de Geografía & Centro UC Desierto de Atacama, Pontificia Universidad Católica de Chile

Fog geographical research in the Coastal Chilean Atacama Desert have a historical backdrop dating back to the mid-20th century. This region remains a subject of substantial scientific interest, with fog research spanning approximately 100,000 km² in northern Chile. Despite a considerable volume of research, our comprehension of the spatio-temporal dynamics of fog climate at a local scale and the driving factors variability behind them remains limited.

Since 2014, a series of eight fully equipped climate stations have been strategically deployed along a regional transect, ranging from the coastal areas to an inland distance of 11 km, encompassing an altitudinal gradient from 518 to 1354 masl. This local network of climate stations enables the acquisition of high-quality climatological data recorded at 10-minute intervals up to the present. Measurements encompass standard fog water content (2 m), 360° fog collectors, air temperature and humidity (2 m), surface temperature (5 cm), wind speed and direction (10 m and 2 m, respectively), air pressure, global radiation, leaf wetness, and dew. Furthermore, fifteen mini standard fog collectors (Mini SFCs) were deployed at the outset of 2019, covering a localized surface area of approximately 3 km². These collectors yield monthly data regarding near-surface fog water collected at a height of 50 cm above the ground.

At the regional scale, the findings illustrate seasonal, monthly, and daily oscillations in fog occurrence, exhibiting variations from the coastal zones toward the inland regions and vice versa. On a local scale, the modelling of near-surface fog variability reveals a profound correlation with the roughness of the terrain.

By elucidating the distinctive features of fog collection and events, as well as describe the driving factors variability, this study endeavours to propel our current understanding of the dynamic interaction of the regional and local fog variability within the unique climatic context of the Coastal Atacama Desert.

Messung und Monitoring

A compact and customisable real-time weather monitoring system, first data and outreach in Freiburg, Germany

Gregor Feigel[1], Marvin Plein[2], Matthias Zeeman[1], Andreas Christen[1]

[1] Chair of Environmental Meteorology, Freiburg im Breisgau, Germany

[2] Chair of Biometry and Environmental System Analysis, Freiburg im Breisgau, Germany

Climate adaptation and emergency management in cities present significant challenges that can be addressed through the incorporation of real-time weather, air quality, exposure, and vulnerability data. However, existing commercial sensor network solutions often lack the necessary characteristics and wide spectrum of observed variables require to map average conditions and weather extremes at the street-level, capturing intra-urban variabilities and microclimates that directly impact people. In response, we have developed a custom two-tiered sensor system, deployed on city-owned street lights in Freiburg, Germany. The system currently consists of 13 self-developed "Tier-I stations" and 29 commercial "Tier-II stations" (LoRAIN NBIoT, Pessl Instruments GmbH), aimed at providing a modular, user-friendly Wireless Sensor Network (WSN) with high spatial density and temporal resolution for research and public use.

Our Tier-I stations were designed from the ground up, including the printed circuit board (PCB), to support temporally high-resolution WSNs, to accommodate a wide range of sensors, and to allow for expandability. The setup is easily expandable through the addition of predefined sensors to a configuration file, and each station seamlessly integrates itself with the server and other processes. Remote access, bidirectional communication, and task distribution protocols further enhance system modularity and ease of maintenance. In addition to air temperature, humidity and precipitation measured by the Tier II stations, the Tier-I station feature a ClimaVUE 50 all-in-one weather sensor and a BlackGlobe (Campbell Scientific, Inc.) that provides data on wind, radiation, pressure, lightning, solar radiation and black globe temperatures which allows for real-time calculation of thermal comfort indices.

The near-real-time data can be accessed through our self-developed "uniWeather" iOS app and API, facilitating data-driven decision-making and public outreach. In addition, we will discuss the spatiotemporal heat stress patterns in Freiburg based on the first full year of measurements at one-minute resolution.

Vergleich von Niederschlagsmessungen an Klimareferenzstationen in Deutschland

Isabel Knerr, Karsten Friedrich, Dr. Frank Kaspar, Dr. Florian Imbery

Um konsistente Zeitreihen von Klimabeobachtungen zu gewährleisten, führt der Deutsche Wetterdienst (DWD) Parallelmessungen an Klimareferenzstationen durch. An ausgewählten Standorten mit unterschiedlichen Umweltbedingungen werden über mehrere Jahre Parallelmessungen mit unterschiedlichen Generationen von operationellen Messsystemen durchgeführt, um die Qualität der gewonnenen Daten zu bewerten, systematische Unterschiede zwischen den Gerätetypen zu analysieren und die Homogenität der Datenreihen zu gewährleisten.

In diesem Beitrag werden zwei Typen von automatischen Niederschlagssensoren miteinander verglichen. Das aktuelle operationelle Instrument (rain[e]) misst mit einem kombinierten Messverfahren, bei dem kleine Niederschlagsmengen gewogen und größere Mengen mit Hilfe einer Kippwaage erfasst werden. Das bisherige Gerät (PLUVIO) misst die Niederschlagssummen mit Hilfe einer Wägemethode. Beide Geräte ermöglichen Messungen mit einer zeitlichen Auflösung von bis zu einer Minute. Neben den unterschiedlichen Messgeräten unterscheidet sich auch deren Ausstattung, da das neue Instrument (Rain[e]) mit einem Windschutz nach Tretjakov ausgestattet ist.

Ein Schwerpunkt unserer Untersuchungen lag auf der Analyse von extremen meteorologischen Situationen. Insbesondere wurden Messungen bei hohen Windgeschwindigkeiten und bei hohen Niederschlagssummen verglichen, wobei der PLUVIO in beiden Fällen den Niederschlag unterschätzte. Bei niedrigen Temperaturen hingegen unterschätzen das Rain[e]-Instrument die Niederschlagsmengen.

WINSENTvalid - UAS Measurement of meteorological data in complex terrain including a wind energy test site

Lukas Gruchot, Kjell zum Berge

The rapid expansion of renewable energies is extremely important to reduce CO_2 emissions in order to mitigate the consequences of the anthropogenic climate change. Electric power generation accounts for the largest share of global CO_2 emissions (International Energy Agency, 2023) and is also the easiest sector to decarbonize. The expansion of wind energy is an important part of the said energy transition. As part of the WINSENT project, a wind energy test site was built in mountainous complex terrain, which is an important contribution to the research of wind energy sites in mountainous complex terrain. It is located on the Swabian Alb, west of the escarpment in the municipality of Geislingen an der Steige. The site is unique due to its location directly behind a steep, forested terrain edge and its equipment including research wind turbines (RWT) and measuring masts, allowing the investigation of the turbulent overflow of the seasonally changing slope and the installations with measurement masts and RWT. The University of Tübingen contributes by in-situ measurements with unmanned aircraft system (UAS) at the test site. The UAS are operated in the inflow, on the slope, above and behind the test site and are resolving turbulent fluctuations down to the submeter range. Several measurement campaigns (IOPs) have already been carried out in the previous WINSENT project. In the WINSENTvalid project, the numerical models developed by WINSENT are to be validated by in-situ measurement data collected by further IOPs. Furthermore, the influence of the newly built RWT on the flow is investigated by comparison to pre-construction data. The presentation will focus on the introduction of the test site, the conducted IOPs and a showcase of initial measurement data.

Scaling

The Central Europe Refined analysis version 2 (CER v2): An improved gridded long-term dataset based on dynamical downscaling

Frederik Bart, Xun Wang, Dieter Scherer, Benjamin Schmidt, Fred Meier, Marco Otto

The Central European Refined analysis (CER) was developed in 2016 as a high-resolution, reanalysis-based and gridded dataset for Central Europe. The second version of this dataset (CER v2) aims to further improve the performance of CER with a particular focus on hydrometeorological variables. Major changes from the precursor version include the use of a new WRF version (4.3.3), new forcing data (ECMWF-ERA5 reanalysis) and a different microphysics and cumulus scheme. The simulation setup consists of two two-way nested domains. The largest domain covers all of Germany with a 10 km grid spacing, while a second domain covers the Berlin-Brandenburg region with 2 km grid spacing. The WRF simulation uses a daily re-initialization approach, adopted from the High Asia Refined analysis (HAR), with consecutive 36-hour runs beginning at 12:00 UTC and including an initial 12-hour spin-up period. This prevents strong deviations from the ERA5 forcing data and allows for parallel runs in any order. Other significant changes from the previous CER version include the use of the Kain-Fritsch cumulus and the Thompson microphysics scheme, which were selected based on sensitivity studies using combinations of six preselected cumulus and six microphysics schemes. At this time, CER v2 products for the surface layer of the 2 km domain have been computed in NetCDF format for 33 years (1990-2022) and are available for download (https://data.klima.tu-berlin.de/CER/v2/). Further releases of three-dimensional fields and additional years are in progress, and CER v2 will be continuously updated along with the release of new ERA5 data by ECMWF.

The use of CER v2 data for hydrometeorological studies was a focus of development. Daily data from the German Weather Service within the 2 km domain for the period from 1991 to 2020 were used to evaluate CER v2 precipitation results. The performance of the dataset was evaluated using performance metrics such as mean bias and root-mean-square error, as well as contingency tables for signal detection and skill scores. CER v2 data will be used in case studies in the Climate and Water under Change (CliWaC) project to examine differences in the magnitude of decreasing lake levels near Berlin. In addition, the dataset is being used in the AI-NET-PROTECT project for the investigation of rainfall-specific signal attenuation of high frequency wireless communication within Berlin and Brandenburg.

Downscaling of climate change scenario ensembles to city-wide and high-resolution thermal comfort maps using deep learning

Briegel, F.; Schrodi, S.; Wehrle, J.; Sulzer, M.; Brox, T.; Schindler, D.; Christen, A.

We present a high-resolution building-resolving outdoor thermal comfort model (HTC-NN) based on deep learning that has an excellent trade-off between computational cost, complexity, and accuracy when compared to commonly used numerical urban climate models. The proposed deep learning approach is an emulation of different existing numerical urban climate models at different scales and predicts the Universal Thermal Climate Index (UTCI) at pedestrian level based on meteorological forcing and geospatial data on building form, land cover, and vegetation. Street-level measurements from a dense urban sensor network in Freiburg, Germany, are used to evaluate the model. The mean absolute error over a one-year period is 2.3 K.

The deep learning model is used to downscale climate projections to citywide high-resolution (1 x 1 m) outdoor thermal comfort maps for the city of Freiburg, comparing ensembles of three different greenhouse gas emission scenarios (Representative Concentration Pathway – RCP) for the years 2070–2099 with the current climate of downscaled reanalysis data for the years 1990–2019. The changes in the urban climate under the RCPs 2.6, 4.5 and 8.5 are examined.

The simulations show that future UTCI distributions in Freiburg will shift towards higher and more extreme values. In addition, neighbourhood-averaged thermal comfort conditions vary widely between neighbourhoods, even when assigned to the same local climate zones, e.g. due to differences in age and degree of urban vegetation. The simulations also show contrasting differences in the location of hot spots during the day and at night. In addition, the presentation will highlight several other applications of the model. We can assess the effectiveness of adaptation measures in future climates by modifying the geospatial input data on urban form, for example by adding and removing trees and changing buildings. In addition, the model can be used to investigate the drivers of thermal comfort at different scales.

Der Einfluss von stratiformen und konvektiven Niederschlag auf den d18O Wert von Regen: eine hochauflösende Modellstudie für Ecuador mit dem Isotopen-fähigen COSMOiso Klimamodell

Nadja Landshuter, Thomas Mölg

Das Klima der Erde kann über indirekte Anzeiger, sogenannte Proxys, rekonstruiert werden. Dazu zählt unteranderem das Isotopenverhältnis (d18O) zwischen den stabilen Sauerstoffisotopen 18O zu 16O in Baumringen, welches durch das aufgenommene Wasser (H2O) in einem Baum manifestiert wird. Die hydrologischen Bedingungen, unter denen der Baum gewachsen ist, werden auf diese Weise konserviert. Das Verständnis über die atmosphärischen Einflussfaktoren auf das stabile Isotopenverhältnis des Niederschlags ist folglich essenziell für eine fundierte isotopenbasierte Rekonstruktion des Klimas.
Die Analyse von gemessenen stabilen Isotopen des Niederschlags sowie atmosphärischen Satelliten- und Klimamodelldaten führte zu einem soliden Grundwissen. Durch die Implementierung von stabilen Isotopen in den hydrologischen Kreislauf von globalen Klimamodellen konnten nicht nur atmosphärische Prozesse mit deren Isotopensignatur verknüpft, sondern auch zeitlich und räumlich kohärente Datensätze geschaffen werden. Regionale und hochauflösende Klimamodellläufe mit Isotopendaten sind kaum vorhanden, aber notwendig, da Proxys von lokalen und regionalen Prozessen beeinflusst werden. Dazu zählt insbesondere die niederschlagsgenerierende atmosphärische Konvektion, welche erst bei einer räumlichen Modellauflösung kleiner als 10 km explizit simuliert werden kann. Aktuelle Studien zeigten ein angereichertes Isotopensignal für konvektiven im Vergleich zu stratiformen Niederschlag. In unserer Studie untersuchen wir diesen Zusammenhang mit Hilfe des hochauflösenden und Isotopen-fähigen COSMOiso Modells anhand der von Januar bis April andauernden Regenzeit im tropischen Süd-Ecuador. Unsere Analyse zeigt, dass eine einfache Unterteilung zwischen stratiformen und konvektiven Niederschlag nicht ausreicht und die Einführung einer zusätzlichen Gruppe, der niedrigen Konvektion, notwendig ist. Durch den vorherrschenden Niederschlagstyp können Rückschlüsse auf den d18O Wert im Niederschlag gezogen und die Unsicherheiten bei der Interpretation von klimatischen Proxydaten verringert werden.

Klimawandel – Klimawandelanpassung

Die Veränderung der zehn phänologischen Jahreszeiten in Deutschland über den Zeitraum 1951 bis 2019 und der Bezug zum Klima

Lisa Pfeuffer

Die Auswirkungen des Klimawandels können bereits in vielen physikalischen und biologischen Systemen nachverfolgt werden. Die Phänologie ist eine Wissenschaft über die natürlich, wiederkehrenden Erscheinungsphasen der Pflanzen und ein möglicher Indikator, dass die steigenden Temperaturen auch Auswirkungen auf die Vegetation der Pflanzen haben. Die große Menge an archivierten Daten ermöglichen es, die verschiedenen Eintrittserscheinungen der phänologischen Phasen auf Veränderungen über längere Zeiträume zu untersuchen. Neben den Aufzeichnungen des Deutschen Wetterdienstes (DWD) haben bereits lokale und globale Analysen stattgefunden, die die Veränderungen der phänologischen Jahreszeiten untersuchen. Dabei wurde bereits die Verfrühung des Frühlings sowie die Verlängerung des Herbstes und der Vegetationsperiode festgestellt.

Die Arbeit, die in dem Vortrag präsentiert werden soll, untersucht die Veränderungen der zehn phänologischen Jahreszeiten in Deutschland über einen Zeitraum von fast 70 Jahren. Dabei wurde bestätigt, dass auch in Deutschland eine Tendenz zur Verfrühung des Beginns des phänologischen Frühlings vorliegt. Auch fast alle anderen phänologischen Jahreszeiten beginnen immer früher, dies deutet auf eine Verschiebung in Richtung Jahresbeginn hin. Es kann auch gezeigt werden, dass sich die Dauer des Herbstes verlängert hat. Daraus ergibt sich, dass der Winter neben der Verfrühung des phänologischen Frühlings auch Tage zugunsten des phänologischen Herbstes verliert. Ein kürzerer Winter bedeutet eine längere Vegetationsperiode. Diese Veränderungen der phänologischen Jahreszeiten könnten an der Veränderung des Klimas liegen. Untersucht wurde der Zusammenhang mit der Lufttemperatur, da dieser meteorologische Parameter die größte Wirkung auf die Pflanzen zeigt. Mithilfe von durchschnittlichen Lufttemperaturen konnte gezeigt werden, dass auch in Deutschland eine Temperaturerhöhung über die letzten 140 Jahre stattgefunden hat. Bei dem Vergleich dieser Tendenz mit den Veränderungen der phänologischen Jahreszeiten konnten mögliche Zusammenhänge erkannt werden.

Climate Twins - Klimatisch vergleichbare Städte und ihre Herausforderungen und Potenziale als integrierter Planungsansatz zur urbanen Klimawandelanpassung*

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Klimawandelbedingte Auswirkungen wie Hitze- oder Trockenstress für Menschen, Tiere und Pflanzen treten insbesondere in städtischen Gebieten auf. Da diese Situationen keine Einzelphänomene darstellen, sondern in ein globales System eingebettet sind, hat sich die Suche nach ähnlichen Problemen in anderen Städten oder Ländern mit anschließender Übertragung von Lösungen als bewährter Ansatz entwickelt. Aus diesem Blickwinkel betrachtet, liegt ein großes Potenzial in der Betrachtung und Analyse von städtischen Strukturen und dessen Morphologie, deren aktuelles Stadtklima ein zukünftiges Abbild für andere Städte darstellt. Unter den Begriffen "Climate Twins" oder auch „Climate Analogues“ werden diese speziellen Klimaprognosen erforscht (Schauser und Renner 2021; Bastin et al. 2019; Hallegatte et al. 2007). Die Vergleiche sollen veranschaulichen, wo auf der Erde das prognostizierte Klima für eine bestimmte Stadt bereits heute anzutreffen ist, also als klimaäquivalent bezeichnet werden kann.

Die vorliegende Forschungsarbeit nutzt diese Vergleiche um integrierte – stadtklimatologische und raumplanerische – Fragestellungen, Herausforderungen, aber auch Potenziale zu entwickeln, die sich auf die drängende Frage der Anpassung an den Klimawandel im Spannungsfeld von städtebaulicher Dichte und Grün- und Freiraumplanung beziehen.

Die zunächst spezialisierte Perspektive seitens der Klimaforschung stellt mithilfe dieser äquivalenten Situationen einen Erklärungspfad her, welche folglich auch Richtungssicherheit für die Raumplanung und damit eine Zukunftsperspektive ermöglicht. Flankierend dazu bietet der raumplanerische Zugang die weiterführenden Schritte hinsichtlich einer optimierteren städtischen Klimawandelanpassung in den wissenschaftlichen, aber auch planungspraktischen Diskurs zu bringen. Damit wird ein Brückenschlag in die angewandte Stadtklimatologie angepeilt, welcher im angesprochenen Spannungsfeld von immenser Relevanz ist.

Mit diesem Beitrag werden die sich überlappenden Herausforderungen und Diskussionspunkte aus den zwei Fachrichtungen thematisiert. Die von Erell et al. (2011, S. 145ff) formulierten Kriterien für mikroklimatische Gestaltungsstrategien für den urbanen Raum dienen dabei als Rahmengerüst. Des Weiteren dient das Feedback zum Vortrag als Grundlage für den weiteren Verlauf der Forschungsaktivitäten (insbesondere für die Konzeption einer Fallstudie zu „Climate Twins“ im europäischen Raum).

*** Vortrag entfällt!**

Assessing the divergence problem in north-west North American tree-ring data

Marcel Kunz[1], Rob Wilson[2], Emily Reid[2], Jan Esper[1]

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Tree-ring data are an ideal proxy to reconstruct annual climate variability over the Common Era. However, an offset between warming instrumental temperatures and the trends derived from tree-ring data has been observed since the 1960s in various regions across the Northern Hemisphere while others remained less affected. This “divergence problem” represents a loss of temperature sensitivity and questions the skill of tree-ring based climate reconstructions to fully represent pre-instrumental warm periods.

Here, we present an assessment of tree-ring width (TRW) and maximum latewood density (MXD) data from the Canadian Yukon and neighboring Alaska, an area showing a spatially and temporally diverse influence of this phenomenon. We provide new evidence from recent white spruce (Picea glauca) field campaigns including sampling of young and old trees, explore the effects of detrending methodology on long-term TRW and MXD trends, and compare findings from classical X-ray-based measurements with novel blue intensity data. As part of a larger network, our results could be upscaled to larger regions of the Northern Hemisphere and may help to improve our understanding of the causes of the divergence problem.

Klimawandel – Klimaextreme

Long-term summer flow variability of the Morava River, Czech Republic

M.C.A. Torbenson, R. Brázdil, J.H. Stagge, J. Esper, U. Büntgen, M. Hanel, O. Rakovec, M. Trnka

Hydrological summer extremes represent a prominent natural hazard in eastern Czech Republic. Low river flows constrain transport and water supply for agriculture, industry and society, and flood events are known to cause devastation and fatality. Understanding changes in the frequency and magnitude of hydrological extremes is, however, associated with great uncertainty due to the limited number of gauge observations. Here, we compile a tree-ring network to reconstruct July-September baseflow variability of the Morava River from 1745-2018 CE. An ensemble of reconstructions was produced to assess the impact of calibration period length and trend on the long-term mean of reconstruction estimates. The final calibration is the first baseflow reconstruction based on tree rings from the European continent. Simulated flows and historical documentation provide quantitative and qualitative validation of estimates prior to the 20th century. The reconstructions indicate an increased variability of warm season flow during the past 100 years, with the most extreme high and low flows occurring after the start of instrumental observations. The negative trend in baseflow displayed by gauges across the basin after 1960 is not unprecedented however, and it is therefore likely that even lower flows could occur if considering hydroclimate and temperature-driven evaporation demands separately.

Characteristics and hazard assessment of hailstorms in the western Alpine region

Katharina Schröer, Simona Trefalt, Alessandro Hering, Luca Nisi, Urs Germann, Cornelia Schwierz

Convective precipitation events are associated with damaging atmospheric hazards, such as torrential rainfall, wind, and hail. Hail in particular causes annual damages in the millions, with agriculture, buildings, and vehicles being most affected. Observation of these events is hampered due to the small spatio-temporal scales involved, a situation that is exacerbated over complex terrain. Within the hail climatology Switzerland project, an extensive observational hailstorm dataset was established based on radar data using two hail and thunderstorm tracking algorithms to obtain detailed storm track information as well as individually resolved hail footprints. We developed a hierarchical probabilistic hazard model connecting large-scale conditions to local storm properties. This framework allows to generate plausible stochastic event sets that either stay closely to observations or include more speculative, but risk-relevant “what-if”-storylines to be used in risk modeling. Despite all achievements, however, challenges remain in the quantification, communication, and consideration of uncertainties.

Exploring the paleoclimatic potential of Arctic driftwood, Germany

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The Arctic is not only one of the world's most sensitive regions regarding global climate change but is also characterized by too short meteorological observations. This emphasizes the urgent need to establish long-term proxy-based climate reconstructions to set recent anthropogenic forced warming into perspective. Arctic tree rings offer the unique opportunity to gain climate information in unprecedented spatiotemporal resolution. Here, we discuss the potential of well-preserved driftwood originating from the circum-Arctic boreal forests and deposited across the Arctic shorelines. Directly reflecting past sea ice conditions and Arctic Ocean circulation driftwood enables unique insight into Arctic Ocean currents across the Holocene. Moreover, the high temperature sensitivity of the Arctic samples not only allows for retracing their origin but also enables multi-millennia and high-resolution reconstruction of climatic conditions. This topic is particularly timely as the Arctic driftwood archive is threatened by the exhilarating impact of climate change.

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Classification of fog using harmonized time series cross-calibrating two Meteosat generations

Sheetabh Gaurav, Boris Thies, Sebastian Egli, Jörg Bendix

Fog is a meteorological phenomenon that causes horizontal visibility to be less than 1000 meters. Its occurrence has significant socio-economic and environmental consequences. Current long-term research on the fog occurrence based on station data have indicated that the frequency of fog has decreased over Europe since the 1960s. However, due to a limited number of ground-based observations, primarily in low-altitude areas, there is insufficient evidence to support the hypothesis that fog is decreasing across Europe. In order to scientifically investigate different factors, which might be responsible in influencing fog formation over the years over space and time, there is a need of long term consistent satellite data time series to analyze the fog distribution. In this study, first a machine learning based methodology has been developed and implemented to harmonize the two generation Meteosat datasets, i.e. Meteosat First Generation (MFG) and Meteosat Second Generation (MSG) to generate a long-term consistent dataset (1991-2020) which can be further used to classify fog over the European domain (WMO region VI). For this, a Random Forest (RF) based model is trained during the overlap period (2004-2006) of MFG and MSG datasets, to synthesize MFG data from MSG data to generate a consistent MFG time series. The results of this model indicates a good match of synthesized MFG datasets with the original MFG datasets during the overlap period with mean absolute error (MAE) of 0.7 K for the WV model and 1.6 K for the IR model and out-of-bag (OOB) R^2 score of 0.98 for both models. In the next stage, this harmonized dataset is currently being investigated along with the CM-SAF cloud mask dataset to generate a homogeneous cloud mask over the domain, which can be used to finally classify the fog occurrences by combining the harmonized MFG WV and IR channels with cloud base altitude (CBA) and visibility information from Meteorological Aviation Routine Weather Reports (METAR) and synoptic weather observations (SYNOP) in a machine learning based model. Here, we present the current ongoing progress and the preliminary results in generating a 30 years fog climatology (1991-2020) for Europe with a temporal resolution of 30 minutes using this dataset.

Characterization of fog and low clouds in Southwest Germany with satellite and ground-based observations

Maria-Laura Pinilla, Eva Pauli, Hendrik Andersen, Jan Cermak

In this study, fog and low clouds (FLC) are characterized in Southwest Germany using a combination of satellite and ground-based observations.

FLC are an important part of the climate system and impact traffic safety, air quality, the local radiation budget and thereby ecosystem functions. While FLC have been investigated in Europe using satellite data, regional studies are still needed for a better understanding of FLC patterns and processes. Moreover, the use of ground-based data helps to improve satellite retrievals of FLC and assists in the interpretation of the satellite retrievals and the analysis of FLC.

Here, the geographical and seasonal patterns of FLC occurrence and the influence of topography, meteorological factors and aerosols are analyzed. This is done by a statistical evaluation of FLC patterns and processes using satellite and ground-based data sets. Results suggest an influence of topography on FLC occurrence in Southwest Germany, for example over the Black Forest. Meteorological factors, such as wind patterns, are expected to significantly impact FLC cover in the study area. Future studies may implement machine learning to model the influence of FLC drivers on FLC cover.

Separating fog from low stratus clouds on a satellite product using meteorological reanalysis data and machine learning

Viola Hipler, Hendrik Andersen, Jan Cermak

The regular occurrence of fog is essential for the survival of many organisms in the Namib desert, as is shown by physical and behavioural adaptations of animals and plants to exploit fog water. For this reason, precise spatio-temporal information about fog occurrence over the Namib desert region is of great value. Geostationary satellite observations have an excellent potential for monitoring, forecasting, and studying fog over different regions. To this date, several algorithms have been developed for classification of fog based on such observations. Such algorithms, however, often cannot differentiate between fog and low cirrus clouds and treat them as a single category (FLS). That is because from the satellite imagery perspective, the cloud-base-altitude is the only real difference between the two (fog: touching the ground; low stratus: above ground). Local meteorological variables from reanalysis, such as relative humidity, could help identifying situations in which the cloud is touching the ground. In this study we present an analysis performed on ground based measurements to identify the relevant variables for distinguishing between fog and low clouds. This is especially interesting as the origin and formation mechanisms of fog in the Namib are still subject of debate. A combination of reanalysis data and a state-of-the-art FLS detection product will then be used to train a neural network on distinguishing fog situations from low stratus. The poster will present preliminary findings on meteorological situations at fog vs. low stratus conditions and showcase the potential of machine learning to discriminate between the two. A reliable dataset of fog events in the Namib could help analysing the role of fog in the local ecosystems or provide a data base for future fog forecasting.

Abstract zum Poster

Reduzierung städtischer Wärmeinseln durch den Einsatz blattwendender Baumarten?

Judith Geib, Sascha Henninger

Die Herausforderungen des fortschreitenden Klimawandels sind längst zum Handlungsbedarf in der Stadtentwicklung geworden. Zahlreiche Forschungsarbeiten und Pilotprojekte aus dem Bereich der angewandten, planungsorientierten Stadtklimatologie können dazu beitragen, Strategien und Konzepte für eine klimaangepasste Stadtentwicklung auf den Weg zu bringen.

Steigende Temperaturen und Veränderungen im Niederschlagsregime sind spürbare Folgen des Klimawandels. Sie wirken sich auf die für Mitteleuropa typische Baumartenzusammensetzung aus und werden zwangsläufig zu Arealverschiebungen und erhöhter Baummortalität führen. Neben den Waldbeständen geraten auch die heimischen Stadtbäume zunehmend an die Grenzen ihrer Anpassungsfähigkeit, wobei kontinental geprägte Arten häufig eine höhere Stresstoleranz und damit Vitalität aufweisen. Insbesondere blattwendende Baumarten rücken im Zuge des Klimawandels zunehmend in den Fokus. Ziel des Forschungsvorhabens ist es daher, den Einsatz von Laubbaumarten als mögliche Anpassungsstrategie an sich verändernde klimatische Rahmenbedingungen im urbanen Raum zu untersuchen. Der Fokus liegt dabei auf der Analyse der sich verändernden Albedo und der abnehmenden Oberflächentemperatur im Kronendach der Silberlinde „Tilia tomentosa“.

Die Silberlinde, eine wärmeliebende Pflanze, stammt ursprünglich aus Südosteuropa. Sie wurde bereits 1767 in gärtnerischen Kulturen eingeführt und ist in Europa seit Jahrzehnten eine beliebte Baumart für urbane Gebiete. Gerade im Hinblick auf den Klimawandel gewinnt sie zunehmend an Bedeutung, da sie im Vergleich zu anderen Lindenarten (z. B. Winterlinde) sowohl Hitze als auch Luft- und Bodentrockenheit besser verträgt. Dies ist auf ihre zahlreichen Anpassungen an Trockenstress zurückzuführen, wie z. B. die silbrigen Blattunterseiten und die Fähigkeit, bei starker Sonneneinstrahlung die helle Blattunterseite der Sonne zuzuwenden.

Die in-situ Messungen werden an sechs Standorten in Kaiserslautern durchgeführt. Die Auswahl der Standorte erfolgt gezielt nach geeigneten Kriterien. Mithilfe von hochauflösenden Wärmebildaufnahmen und weiteren Temperaturmessungen wird die Abnahme der Lufttemperatur unter der Baumkrone und im Stammraum erfasst. Zusätzlich wird die Abnahme der Oberflächentemperatur der Baumkrone aufgrund der veränderten Albedo quantifiziert. Weiterhin werden Wärmebildaufnahmen der umliegenden Bestandsgebäude erstellt, um eine mögliche Reaktion der Gebäudefassaden durch die reflektierte Strahlung der Blattoberflächen verifizieren zu können. Die Aufnahmen der Wärmebildkamera sowie meteorologische Parameter (Lufttemperatur, Luftdruck, Windgeschwindigkeit und -richtung, relative Luftfeuchte, Beleuchtungsstärke, Bodenfeuchte und UV-Index) werden zur Identifikation des Stimulus „Blattwende“ herangezogen. Anhand von Nahaufnahmen der Blätter im Kronendach werden zusätzlich die Geschwindigkeit und die Dauer der Blattdrehung erfasst, um die zeitliche Dimension einordnen zu können. Da die Straßenbaumliste der GALK (Stand 2023) Unterschiede in der Eignung verschiedener Arten der Silberlinde als Straßenbaum ausweist,

bezieht sich die Untersuchung auf Tilia tomentosa Brabant (gut geeignet) und Tilia tomentosa (bedingt geeignet). Darüber hinaus wird der Einflussfaktor der Entwicklungsphase bei den Messungen berücksichtigt. Da Bäume je nach Lebensphase auf unterschiedliche Anpassungsstrategien zurückgreifen, werden die Silberlinden in die Phasen „Jugend“, „Reife“ und „Alter“ eingeteilt und untersucht. Auf diese Weise kann festgestellt werden, ob in einer bestimmten Entwicklungsphase die Fähigkeit zum Drehen der Blätter dominiert. Sollte die Silberlinde nachweislich lokalklimatische bzw. mikroklimatische Auswirkungen auf ihre unmittelbare Umgebung haben, ergeben sich daraus entsprechende Handlungsempfehlungen für die Stadtplanung, insbesondere im Hinblick auf die Frage, welche Anforderungen an die grüne bzw. grün-blaue Infrastruktur in der Praxis des Stadtumbaus hinsichtlich der Nutzung des öffentlichen Raumes, des Einsatzes des „richtigen" Stadtgrüns und entsprechender Gestaltungsfragen bestehen. Es können Handlungsempfehlungen entwickelt werden, die gestalterische Strategien und städtebauliche Konzepte aufgreifen und somit durch gezielte Anpassungsmaßnahmen zur Reduzierung der städtischen Wärmeinsel beitragen.

Urban modification of the atmospheric boundary layer over and downwind of Paris – first insights from intensive profiling observations in summer 2023

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Improving understanding of urban atmospheric boundary layer (ABL) processes and dynamics is central to improving the modelling and forecasting of weather, air quality, and thermal comfort. Here, we report on an intensive observations period (IOP) on urban ABL dynamics during summer 2023, conducted as part of the ERC (European Research Council) urbisphere-Paris measurement campaign and undertaken in collaboration with the Institute Pierre-Simon Laplace.

To explore surface-atmosphere feedbacks, extensive in-situ and remotely sensed observations from a network of automated lidars and ceilometers (ALC), doppler wind lidars, radiometers, sun photometers, and automatic weather stations are used. Operating from January to December 2023, the network consists of ten ALCs deployed on transects both along, and perpendicular to, the predominant wind direction in Paris. The along-wind transect extends 60 km upwind and downwind of the city centre and includes the rural periphery of the city, allowing urban modifications of the ABL profile to be observed as air moves into, across, and beyond the metropolitan area. The observations will be used to understand the magnitude and interplay of heat fluxes, radiation fluxes, aerosol emissions, and boundary layer dynamics and eventually to evaluate new weather and air quality modelling approaches.

During the IOP, additional temporary mobile measurements are undertaken including transect measurements with a van-mounted ALC and balloon radiosonde releases within the city and beyond to gain an in-depth understanding at a high spatial resolution of the vertical profiles of attenuated backscatter, linear depolarisation ratio, air temperature, humidity, and wind characteristics. Through concurrent observations, urban-rural differences can be investigated, with downwind measurements exploring the urban plume. With multiple balloon launches during one day the temporal evolution of the ABL can be explored. This contribution will highlight selected and initial results from the IOP measurements to showcase influences of the megacity of Paris on the ABL.

Abschätzung der Wirksamkeit von Luftreinigungssystemen, im Umfeld eines verkehrsreichen Strassenabschnittes (München, Landshuter Allee) mittels Low-Cost Messsystemen.

Christoph Beck, Lisa Falkenrodt, Verena Fricke, Carlos Pusch, Florian Reich, Jonathan Simon, Andreas Philipp

Im Rahmen des vom Bayerischen Staatsministeriums für Umwelt und Verbraucherschutz seit November 2020 geförderten Verbund-Forschungsprojekts REINELUFFT? (Reinigen neue Luftfiltersysteme von urbanem Stickstoffdioxid?) untersucht das Augsburger Teilprojekt MESSNETZ, auf der Basis von Low-Cost Messungen, die raum-zeitliche Variabilität der NO2-Konzentrationen im Umfeld eines vielbefahrenen Abschnitts der Landshuter Allee in München.

Neben anderen Einflussgrößen (Wetterlage, lokale Meteorologie, verkehrsbedingte Emissionen) werden hierbei insbesondere auch variierende Betriebszustände von insgesamt neun – seit Herbst 2021 entlang des betrachteten Strassenabschnitts betriebenen – Luftreinigungssystemen berücksichtigt, mit dem Ziel eine potentielle Reinigungswirkung der Filtersäulen zu quantifizieren.

Erste Auswertungen von NO2-Konzentrationsabschätzungen im erweiterten Umfeld der Filtersysteme ergeben keine signifikanten NO2-Konzentrationsminderungen durch den aktiven Betrieb der Systeme. Aus der Anpassung des Low-Cost Messnetzes seit Frühsommer 2023 – räumliche Konzentration von Messboxen im Nahbereich eines Reinigungssystems – sind erweiterte Erkenntnisse zur Reinigungsleistung im unmittelbaren Umfeld (wenige Meter Horizontaldistanz) zu erwarten.

Measuring Saharan Dust with the OPC-Pod: A new sensor payload for small uncrewed aircraft systems (UAS)

Martin Schön, Vasileios Savvakis, Maria Kezoudi, Andreas Platis, Jens Bange

Saharan dust regularly travels long distances, sometimes as far north as Iceland, or South America. Across Europe, Saharan dust events regularly lead to low visibility and high concentrations in fine aerosol particles, impacting human health. Saharan dust also influences atmospheric processes, absorbing solar radiation and influencing cloud formation. Numerical models predicting the spread of Saharan dust events have shortcomings, such as underestimating the transport of coarse particles. This highlights the need for accurate and high-resolution measurements of dust events, giving information about the vertical distribution of dust in the atmosphere, as well as the size distribution of the dust itself. We present the new sensor payload OPC-Pod, developed for use on a small fixed-wing uncrewed aircraft system (UAS), based on the optical particle counter (OPC) Alphasense N3, extended by a diffusion dryer, and a passive aspiration system. In combination with an existing meteorological sensor payload aboard the UAS, simultaneous measurements of the 3D wind vector, humidity, temperature, aerosol particle concentration and size distribution up to an altitude of 5500 m above ground level (AGL) are possible. We present results from validation measurements, both in the laboratory and in the field, as well as results showing the development of a Saharan Dust event captured in April 2022 over Cyprus. Over multiple days, the measurements show the development of this event, with significant amounts of dust measured during the event, especially in a layer between 2000 m and 3000 m AGL, and the subsequent reduction in dust concentration over multiple days as the event subsides. Additionally, the size distribution differs between the dust layer and the atmospheric boundary layer, with more coarse particles in the dust layer.

Auswirkung der Klimavariabilität von ENSO und A-ENSO in den Hochlandquellwasserlagunen der venezolanischen Anden

Joel Francisco Mejia, Jose David Gonzalez, Anderson Albarran

Der Einfluss der Klimavariabilität in den Hochland-Quellwasserlagunen der venezolanischen Anden wurde anhand einer ursprünglich definierten Zeitreihe von 46 Jahren bewertet, die mithilfe des Oceanic Niño Index (ONI) klimatologisch typisiert wurde. Mit der Verfügbarkeit von LANDSAT-Bildern wurden 15 klimatologisch unterschiedliche Probenjahre ausgewählt, um das spektrale Verhalten der Wasseroberfläche der Lagune anhand des Normalized Differenz Water Index (NDWI) zu bewerten. Die NDWI-Werte wurden statistisch mit dem ONI und mit lokalen Klimaindikatoren verglichen und die prozentualen Abweichungen der Anomalien bezogen auf ein Standardjahr geschätzt. Die Ergebnisse zeigten, dass die hydrologische Dynamik der Lagunen durch die Kombination von ENSO, Anti-ENSO-Anomalien und neutralen Jahren beeinflusst wird; allerdings ist die Beeinträchtigung unterschiedlich und es wird von drei Bedingungen abhängen: (1) Position der Lagunen in der Landschaft; (2) biophysikalischen Bedingungen der Landschaft; und (3) sequentiellen Intensität der Anomalien. Andererseits war die hydrologische Erholung während Niña-Ereignissen und neutralen Jahren ein vorherrschender Abweichungstrend, wodurch die Feuchtgebiete am empfindlichsten gegenüber Anti-ENSO-Anomalien und hydrologisch widerstandsfähiger waren. Obwohl die Ergebnisse klar und schlüssig waren, haben sie eine begrenzte räumliche und zeitliche Reichweite, da die beteiligten Prozesse sehr komplex sind. Daher ist weitere Forschung erforderlich, um das Verständnis der klimatischen und atmosphärischen Beziehungen in den Prozessen zu ergänzen, die das Hochland der Berge in den Tropen bestimmen.

The efficacy of CO2 fixation as a criterion of ecosystem recovery after climatological extremes

Yana Savytska, Kira Rehfeld

We are living in a period of changing climate and weather extremes. Over the last decades, anthropogenic greenhouse gas emissions have led to clearly detectable surface warming. Superimposed on this trend, summer fires, floods and droughts, occur on timescales of months, days or even minutes.

Both types of extremes, slow and fast-acting, can change ecosystems. The recovery and adaptation processes can be much longer than the impact's duration.

Vegetation is a part of the ecosystem and a natural sink of CO2. Depending on the character and strength of the extreme, the species can adapt to the new conditions or die under this influence. One of the main plant features is photosynthesis, which is directly and proportionally related to the CO2 fixation from the atmosphere. Therefore, the CO2 concentration can be used as an indirect intensity indicator of photosynthesis and connected with ecosystem features.

When extremes break the existing ecosystem’s balance and lead to a high CO2 fixation decrease, recovery is accompanied by a gradual fixation increase. The complete recovery of ecosystem functions leads to a CO2 fixation return to the previous level and spatiotemporal patterns.

The different biophysical parameters, e.g. GPP, NPP, or their sets are often used as state indicators of ecosystem characteristics, but these are potentially less straightforward to estimate in near-real time and may conflate long-term and short-term changes compared to near-surface atmospheric CO2 concentrations which reflect photosynthetic rates. We plan to take the amount of the fixed CO2 and its fluctuation as an indicator of the ecosystem state or functional recovery after an extreme event.

We develop and explore conceptual and statistical models of the changes to local CO2 concentrations as an indicator of ecosystem recovery under the environmental impact. We ask:

- what main processes take place in the ecosystem after the extreme events?

- how do the ecosystems recover after the impact event from the point of primary productivity?

- what biomass production characterizes each recovery phase?

To answer these questions, we will explore the consequences of the extremes during the last decades, e.g. the summer droughts in 2003 in Europe, the heatwaves in Russia (2010). This will allow us to develop and investigate different ecosystems recovery models after extreme impact.

Similar but different? Climate risk archetypes can help the municipal adaption process.

Nils Riach, Rüdiger Glaser

Municipalities are often challenged in adapting to climate change impacts, with knowledge gaps regarding climate risks being an important constraint hindering the development and implementation of adaption strategies. Although at the municipal level, risks are highly context specific, recurring patterns of hazard, exposure and vulnerability can often be identified. While indicator-driven climate risk assessments are widely used, they tend to apply a singular explanatory model instead of addressing the heterogeneity of cases and thus neglect similarities and differences of risk typologies. Such typologies include, for example, winter tourism-dependent municipalities in mountainous areas with declining snow reliability or agricultural communities that are increasingly affected by heat and drought.

Archetype analysis provides a theoretically grounded framework for handling typologies which investigates patterns of a phenomenon at an intermediate level of abstraction, thus allowing for context sensitive generalizations of results. We develop an archetype analysis approach in order to better capture the heterogeneity of local climate risk settings at the municipal scale in the German state of Baden-Württemberg. Using cluster analysis, we derive nine climate risk archetypes with characteristic building block configurations of hazard, exposure & vulnerability indicators. The proposed data-driven approach aims at identifying broad socio-economic structures that are material to the understanding of local climatic risk. It is not the intention of the approach to conclusively explain specific local risks or recommend concrete municipal adaptation measures. Rather, this approach aims to highlight that the structures subject to risk exhibit great heterogeneity, suggesting that although different adaptation needs exist, basic structural data can help explain similarities in climate risk settings. We argue that an approach using archetypes can effectively support the adaption process by improving the understanding of spatial similarities and differences of municipal risks, which can be helpful in identifying archetypical adaptation measures.

Remote sensing of vegetation-water-interactions in the urban area of Hamburg

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Plants in urban areas are exposed to a wide range of environmental stressors that are exacerbated by climate change. At the same time, they perform many important functions, making them indispensable to the urban climate and thus to the urban population.

In addition to an increase in heat waves and droughts, Hamburg is predicted to experience “too much water” in the form of storm surges, river flooding, heavy rainfall events and rising groundwater levels. The complexity of the interactions between these opposing trends, as well as their high spatial variability, makes it impossible to generalise their effects on water availability for urban vegetation. Therefore, there is a need for spatially explicit research on the effects of these changes on vegetation in order to target adaptation measures. In addition, vegetation condition can be used as an indicator to identify water-related changes when measurement data are limited.

Remote sensing methods offer particular potential for investigating changes in vegetation condition over larger areas and time periods. Using time series of Sentinel-2 satellite images with their high spectral, spatial and temporal resolution, we aim to detect variations in vegetation condition as well as short-term greening and browning trends on a cell-wise basis. Statistical and numerical models will be used to relate these variations to meteorological and hydrological drivers to identify the underlying causes of change in order to 1.) determine areas of concern for adaptation planning, and 2.) develop a better understanding of small-scale water changes in the urban area of Hamburg.

Abstract zum Poster

Städtische Auswirkungen auf die planetare Grenzschicht in Berlin und Umgebung während der urbisphere-Berlin Kampagne

Daniel Fenner, Andreas Christen, Sue Grimmond, Fred Meier, Dana Looschelders, William Morrison, Matthias Zeeman, Frank Beyrich, Matthew Clements, Russel Glazer, Lewis Blunn, Simone Kotthaus, Denis Hertwig, Dimitris Poursanidis, Nektarios Chrysoulakis, Dieter Scherer

Im Rahmen des ERC Synergy Grant “urbisphere” wurde von Herbst 2021 bis Herbst 2022 eine meteorologische Messkampagne in Berlin, Deutschland durchgeführt. Der Fokus der Messkampagne lag auf der Untersuchung der Wechselwirkungen zwischen Stadt und regionaler atmosphärischer Grenzschicht auf verschiedenen räumlichen (z.B. Stadt-Umland, innerstädtisch) und zeitlichen (Tagesgang, Jahresgang) Skalen. Dazu wurde insbesondere ein dichtes und systematisches Messnetz von Messgeräten der bodengestützten Fernerkundung (z.B. Ceilometer, Doppler-Wind Lidare) zur Ableitung der Mischungsschichthöhen und des Windprofils aufgesetzt und betrieben, welches die bestehende Messinfrastruktur lokaler Institutionen mit einbezog. Das systematische Messnetz-Design erfolgte unter Berücksichtigung der Stadtstruktur und regionaler Klimabedingungen. Ergänzend dazu wurden u.a. umfangreiche Messungen der Strahlungs- und turbulenten Energieflüsse (Szintillometer- und Eddy-Kovarianz-Systeme) durchgeführt, um die observierten Prozesse und Auswirkungen in der Grenzschicht mit der Energiebilanz der (Stadt-)Oberfläche koppeln zu können. Während kurzzeitiger Intensivmesskampagnen im Frühling und Sommer 2022 wurden zusätzliche Vertikalsondierungen der Grenzschicht mit Radiosonden in Stadt und Umland sowie mobile Messungen mit einem Ceilometer durchgeführt.

Der vorliegende Beitrag soll einerseits die Messkampagne und das Design des Messnetzes illustrieren und andererseits anhand ausgewählter Fallbeispiele zeigen, wie und wann die Stadt Berlin die regionale atmosphärische Grenzschicht und deren Prozesse beeinflusst, inkl. Stadt-Umland-Unterschiede, innerstädtische Variabilität und Advektion städtischer Luft. Zudem soll aufgezeigt werden, wie die unterschiedlichen eingesetzten Messsysteme und das Messnetzdesign, in Kombination mit hochauflösender regionaler dynamischer Modellierung, eine umfängliche Analyse der Prozesse und ihrer Auswirkungen und somit deren tiefer gehendes Verständnis ermöglichen.

Assessing progress in urban climate adaptation: A review of indicators for heat- and water-sensitive urban development

Nisha Patel, Britta Jänicke

An increasing number of cities, both in Germany and Europe, are formulating climate change adaptation strategies to address the consequences of climate change. Nevertheless, quantifying the extent to which these strategies genuinely contribute to alterations in urban infrastructure and promote climate- and water-sensitive urban development remains a challenging endeavour.

The objective of this paper is to identify and evaluate indicators suitable for assessing the implementation of water and heat-sensitive urban development measures in cities at the national or EU level. To accomplish this goal, we conducted an extensive review of literature and existing datasets focusing on indicators that can capture urban development. This will be comprehensible for diverse stakeholders. The data sets for reviewed indicators are accessible from existing datasets or feasible to collect at a national scale. The findings reveal a limited number of studies that have focused on developing indicators for evaluating the implementation of urban climate adaptation strategies at the national or EU level. Overall, we identified five areas, namely surface overheating, green infrastructure, building structure and materials, as well as indicators related to soil sealing and water balance. Different indicators have been used in literature and for smaller study areas or with extensive data preparation such as biometeorological indices, measuring urban heat islands, and Sky View Factor (SVF). For only a select few of these indicators, such as green cover, green accessibility, and surface temperature, datasets are currently available that effectively capture the variability within a city. Overall, this review underscores the necessity for additional research and testing to formulate practical and effective indicators for capturing water- and heat-sensitive aspects of urban development at the national level.

Abstract zum Poster

Klimaanalyse Hitzeaktionsplan Aachen 2023

Gunnar Ketzler, Michael Leuchner

Die Stadt Aachen stellt derzeit einen Hitzeaktionsplan auf, für den klimatologische Basisinformation als Ergänzung zu vorhandenen Klimaanalysen bereitgestellt wurden (Havlik et al.; 2000; Hinzen et al., 2014; Ketzler et al.; 2014). Dabei wurden seit dem Aachener Klimaanpassungskonzept (Stand 2012) bis zum Jahr 2022 eingetretene Veränderungen in drei Dimensionen betrachtet: regionale Temperaturentwicklung, erwartete Temperatur-veränderungen durch Landnutzungsänderungen und Veränderungen der Bevölkerungs-struktur vor dem Hintergrund von Klimaänderungen und Auswirkungen auf die Sensitivität der Bevölkerung.

Die regionale Temperaturentwicklung wurde anhand von Klimadaten des Deutschen Wetterdienstes analysiert; dabei erwies sich die eingetretene Temperaturzunahme 2022 gegenüber 2012 als deutlich (+1,2 K), wobei die Temperaturen in dem betrachteten Jahrzehnt um etwa den doppelten Betrag zugenommen haben als 2012/2014 für 2010-2030 insgesamt erwartet. Die Effekte von Landnutzungsänderungen wurden auf Basis einer Fortschreibung eines geostatistischen Modells analysiert, wobei der Erwärmungseffekt zu etwa 10% der regionalen Temperaturzunahme berechnet wurde (und damit ebenfalls dem Doppelten der für 2010-2030 angenommenen). Es ergaben sich Bevölkerungszunahmen für Gebiete relativ hoher thermischer Belastungszunahme; dem steht ein Rückgang des Kinderanteils und des Anteils Älterer an der Wohnbevölkerung in vielen thermisch belasteten Bezirken (z.B. in der Innenstadt) mit Zunahmen in den thermisch weniger belasteten Außenbezirken gegenüber.

Climate Analysis Heat Action Plan Aachen 2023 (summary)

The City of Aachen is preparing a Heat Action Plan, for which climatological base information in addition to existing climate analysis are provided. A regional temperature increase 2012 to 2022 proved to be about +1,2 K showing about the double value as expected in 2014 for the 20-year period 2010-2030. The effects of land use changes were analyzed with a calculated warming of about 10% of the regional temperature increase (also about the double warming effect expected for the period 2010-2030). Population trends in areas with increasing thermal load are mostly positive while the share of children and elderly people as heat sensitive groups decreased (e.g., in the inner city) and increased in areas with less thermal load.

Data driven Resilience for Dortmund

Benjamin Bechtel, Charlotte Hüser, Swantje Maurer, Panagiotis Sismanidis

Extreme heat endangers human health and well-being and impairs the use of public spaces. Dortmund's Integrated Climate Adaptation Master Plan puts a priority on actions and measures that improve heat resilience. This project aims to support Dortmund in attaining this goal, by deploying a state-of-the-art biometeorological sensor network and developing a nowcasting service for monitoring thermal comfort across the city that will guide on-ground actions and services for smarter urban climate comfort planning. The project aims to pioneer the integration of thermal comfort data in smart-city ecosystems and provide actionable insights for the development of Dortmund's Heat Action Plan. It will use modelled, remotely-sensed, and in-situ data to provide near-real time information about the outdoor thermal conditions through a dashboard where users can explore and visualise current and future climate comfort and human health indicators. Officials from the city of Dortmund will be involved in the design of both the dashboard and the weather station network, to ensure that they meet their needs. The collected data will then be used in a series of on-ground actions for supporting the evaluation of existing climate adaptation measures and the design of new ones. These actions include the mapping of areas with high tree-planting potential, the investigation of changes in human behaviour during hot days, and the assessment of backyard greening strategies. To engage with the local stakeholders, promote the role of citizen scientists, and disseminate the project, a series of workshops and on-site events are also planned (ClimateComfort Labs, bike campaigns etc.). The overall goal of the project is for the city of Dortmund to adopt and integrate these services into its smart-city ecosystem.

Imprints of volcanic degassing in tree rings at the Laacher See, Germany

Frederick Reinig, Frank Keppler, Steffen Holzkämper, Otmar Urban, Lukas Wacker, Max Carl Arne Torbenson, Edurne Martinez del Castillo, Claudia Hartl, Ann-Kathrin Wild, Björn Gunnarson, J. Esper

Once the setting of central Europe's largest Late Pleistocene volcanic eruption, the Laacher See in the East Eifel of Germany is still subject to an active volcanic field. The system continuously emits magmatic carbon dioxide (CO2) through numerous mofettes flanking the shoreline and exposing the overlying ecosystems to elevated and depleted CO2. We here investigate the spatiotemporal influence of volcanic CO2 degassing on local beech (Fagus sylvatica) and oak (Quercus robur) trees by performing tree-ring width, stable carbon isotope, radiocarbon, and chemical composition analyses. Despite some interesting features in the studied proxy data that require further investigations, initial results indicate no impact of volcanic degassing on our diagnostics considering directly exposed and unexposed reference samples. Findings from this approach are expected to support assessments of the potential impacts of magmatic CO2 emissions on surrounding vegetation.

Water and carbon budget over the mountain dry forest (MDF) in the tropical Andes of South Ecuador

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Forest as an ecosystem plays an important role in the carbon sequestration process acting as both, a source and a sink of CO2 varying by vegetation type, seasonality and geolocation. Additionally, the carbon dynamics are strongly driven by climatic factors such as temperature, precipitation and soil moisture, which controls the carbon uptake and release by the ecosystem. The mountain dry forest (MDF) in the tropical Andes of South Ecuador is characterized by a strong seasonality driven by the South American monsoon system. Precipitation occurs particularly from November - May due to north-westerly winds and convective events as the inter-tropical convergence zone (ITCZ) is located further South, while from June till November easterlies and large-scale atmospheric subsidence dominates inhibiting convective activities. Annual rainfall totals reach 325 mm occurring mainly during the rainy season. The vegetation is accordingly determined by deciduous forests, which clearly modifies the water, carbon and surface energy budget along the seasonal cycle. However, the MDF has a substantial role in the climate mitigation and adaption measures by significantly contributing to the global carbon budget, but are at the same time vulnerable to climate change. Rising temperatures and associated higher evaporative demand may lead to considerable variations in the water and energy budget with feedbacks to the carbon sequestration.

An eddy-flux tower over the canopy of the MDF ecosystem in the Laipuna Reserve in South Ecuador was installed to observe and analyze atmospheric CO2/H2O fluxes and microclimatological conditions. The tower is equipped with an open-path Irgason system to obtain net-ecosystem exchange (NEE) and evapotranspiration (ET) as well as additional meteorological sensors to measure precipitation, net-radiation and soil conditions. The study shows first results of the variability in the seasonal cycle of the surface energy components (latent and sensible heat) and the water and carbon fluxes above canopy. Further, NEE is partitioned into its gross components gross primary production (GPP) and ecosystem respiration (Reco) to assess flux variations in the MDF ecosystem as a response to changes in microclimatological conditions. During the dry season lower rainfall and higher temperatures dramatically reduce the carbon uptake down to almost zero, but the ecosystem still shows a carbon neutrality rather than carbon source. With the onset of precipitation events, carbon dynamics are modified with an increase in the sequestration and a clear sink function of the MDF ecosystem.

Assessment of land – atmosphere interactions over agricultural systems in Brandenburg (Germany) using eddy-covariance measurements

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Agricultural ecosystems are highly productive ecosystems that exchange mass and energy through land surface-atmosphere interaction. They are responsible for shaping Earth's surface climate and driving the energy, water, and carbon cycles. At the same time, agricultural systems contribute to uncertainties in the carbon sink of the land and often affect the local water budget through irrigation demands. Thus, it is important to know the carbon and water dynamics as well as the factors driving the exchange processes in order to gain a better understanding of the carbon sink and source variations, and the impact on the local water budget.

Over an apple tree stock in Brandenburg an open-path eddy-covariance (EC) measurement system (Licor Smartflux Measurement Suite) has been installed to observe microclimatic conditions as well as the water and carbon budget on ecosystem level. Agricultural land in Brandenburg covers approximately 45% of its total land area, of which about 75-78% is arable land. The soils are primarily sandy or loamy-sandy, with low levels of organic matter, thus, have a low water holding capacity. Due to its low precipitation (558 mm year−1) in comparison to the rest of Germany (800 mm year−1), Brandenburg is one of the driest regions of Germany, in which summer rains (185 mm) are greater than winter rains (125 mm). In the scope of land use and climate change, such water limited agricultural landscapes are strongly vulnerable to climatic stress situations (e.g. water shortage and drought conditions) which increases the demand for irrigation and might lead to changes in the phenological cycles in the ecosystem associated with feedbacks to the atmospheric water and carbon cycle. The aim of this study is thus, (i) to quantify the carbon and water budget over an agricultural ecosystem and (ii) to analyze atmospheric flux variations and feedback effects to microclimatological conditions to get in-depth insights into the land atmosphere coupling, carbon sequestration as well as water regulation mechanisms.

Based on the surface energy fluxes feedbacks in the partitioning of sensible and latent heat will be examined and discussed in the local water budget. Responses of the agricultural system in terms of carbon sink / source is reflected using net-ecosystem exchange and its partitioning into gross-primary productivity (GPP) and ecosystem respiration (Reco).