IUGG

IACS
International Association of Cryospheric Sciences

IAMAS
International Association of Meteorology and Atmospheric Sciences

IAPSO
International Association for the Physical Sciences of the Oceans

The Virtual Atmosphere-Cryosphere-Ocean seminar series, 19-23 July 2021 (VACO-21)

Monday 19 July, 15:00-17:00 UTC. Remote sensing of the atmosphere, ocean and cryosphere

- Pepijn Veefkind: The impact of COVID-19 policy measures on air quality and climate: the view from space
- Paolo Cipollini: Essential Climate Variables over oceans and ice: a view from space
- Byongjun Hwang: Satellite observation of the floe size distribution of Arctic sea ice: implications for sea ice models

Tuesday 20 July, 15:00-17:00 UTC. Field observations of the atmosphere, ocean and cryosphere

- Laura Stevens: Stress coupling between Greenland supraglacial lakes during rapid drainage
- Markus Frey: Sea salt aerosol from blowing snow above sea ice – observations, modelling and atmospheric impacts
- Joellen Russell: Designing the required Southern Ocean observing system for predicting climate change: robot floats, satellites and supercomputers

Wednesday 21 July, 15:00-17:00 UTC. IAMAS-IACS-IAPSO Early Career Scientist Awards

- Marta Abalos: Human impacts on the stratospheric circulation
- Thomas Wahl: Bigger ships or less flooding? How tidal changes affect flooding along the U.S. coast
- Jessica Fitzsimmons: Micronutrient trace metal dynamics in the Arctic Ocean
- Giulia Mazzotti: Forest snow modelling from tree to regional scales
- David Bigelow: The role of englacial hydrology in the filling and drainage of an ice-dammed lake

Wednesday 21 July, 17:00-17:30 UTC. Coupled changes and variability in the atmosphere, ocean and cryosphere

- Elizabeth Barnes: Machine learning and climate projections

Thursday 22 July, 12:00-13:30 UTC. Coupled changes and variability in the atmosphere, ocean and cryosphere

- Ruzica Dadic: Spatial variability of the sea ice surface (SSL/snow) during MOSAiC
- Matthew England: Global ocean-atmosphere climate teleconnections

Friday 23 July, 15:00-17:00 UTC. Modelling atmosphere, ocean and cryosphere interactions

- Cécile Agosta: Antarctic surface mass balance: local and large-scale drivers, present and future
- Jenny Mecking: Predicting the 2015 North Atlantic Cold Blob
- Doug Smith: Robust but weak multi-model atmospheric response to future Arctic sea ice loss

Registration is free at https://www.eventbrite.co.uk/e/vaco-21-registration-tickets-146559745143

Speaker biographies and abstracts

Marta Abalos (Universidad Complutense de Madrid) obtained her PhD from Universidad Complutense de Madrid, Spain, in January 2014, under the supervision of Encarna Serrano (UCM) and William Randel (NCAR). During her PhD she visited NCAR on several occasions, funded by the Spanish predoctoral fellowship program FPI. Her thesis focused on the dynamical processes driving the variability of tracers in the tropical tropopause layer, a region where the interactions between chemistry, radiation and dynamics are particularly strong. After defending her PhD, she was a postdoctoral researcher at the Laboratoire de Météorologie Dynamique, École Normale Supérieure de Paris (LMD/ENS) in France, where she studied global stratospheric transport variability on interannual and longer timescales in reanalyses. She then carried out a postdoc at the National Center for Atmospheric Research (NCAR), where she worked on future trends in global transport in the upper troposphere and lower stratosphere using the chemistry-climate model CESM-WACCM (Community Earth System Model-Whole Atmosphere Community Climate Model). She has since continued visiting NCAR, fostering collaborations with scientists from NCAR and other research institutions around the world. She was able to return to her home country (Spain) and carry out research at her Alma Mater in 2017, thanks to an "Atraction of Research Talent" Fellowship co-funded by the Cominidad de Madrid and UCM. After this 4-year Fellowship, she obtained an Assistant Professorship at UCM, starting in March 2021. Over the last years, her research has focused on the impact of ozone depletion and recovery, as well as increasing greenhouse gas emissions, on the circulation in the stratosphere. She was a coauthor of the 2018 World Meteorological Organization / United Nations Environmental Panel (WMO/UNEP) Ozone Assessment Report, specifically contributing to the Chapter on Stratospheric Ozone and Climate. She has been recently appointed to be a coauthor again in the 2022 Assessment Report. Her research aims to improve knowledge on the links between stratospheric ozone, climate change and the transport circulation in the stratosphere and upper troposphere.

Human impacts on the stratospheric circulation

The stratospheric mean meridional circulation is a key component of the stratospheric dynamics as it transports heat and tracers globally, thereby influencing the chemical composition and radiative properties of the atmosphere and thus impacting surface climate. It is now well established that this circulation accelerates in response to increasing greenhouse gas emissions. In addition, it has been lately pointed out that the increasing emissions of ozone-depleting substances have contributed a similar amount to the acceleration over the last decades of the 20th century. This contribution reversed sign around the year 2000, as these human-emitted substances are being gradually phased out thanks to the Montreal Protocol protecting the ozone layer. The observational confirmation of these model-based results, however, remains elusive. In the last years, evidence for an acceleration has been obtained for the lower stratosphere, while the disagreement between models and observations still holds in the middle and upper stratosphere. Latest-generation models reveal that the trends in the upper stratosphere are much more uncertain than those in the lower stratosphere, partly due to the crucial role of parameterized gravity waves at those levels.

Cécile Agosta (Laboratoire de Sciences du Climat et de l'Environnement) is a climate scientist specializing in Antarctic studies and snow-atmosphere interactions. She received her PhD at the Glaciology Laboratory of Université de Grenoble, France, and followed up her researches at the University of Liège, Belgium, where she developed an Antarctic setup of the regional atmospheric model MAR. She is now working at the Laboratoire de Sciences du Climat et de l'Environnement (Paris-Saclay, France) in an experimental team to interpret Antarctic vapour and snow isotopic composition with a model-data approach.

Antarctic surface mass balance: local and large-scale drivers, present and future

Here we present some of the main drivers of the Antarctic surface mass balance, focusing on snow accumulation and meltwater run-off. We detail the local processes impacting both terms and then assess the role of large-scale circulation with emphasis on extreme advection events. As both large-scale and local processes are critical to correctly model the Antarctic surface mass balance, we evaluate large-scale fields from CMIP global climate models over the Southern Ocean and then use a polar-oriented regional climate model to perform projections over the 21st century. We show increased snow accumulation over the grounded ice sheet for all scenarios that will mitigate ice losses, while meltwater run-off will significantly increase over ice shelves, causing strongly decreased surface mass balance over ice-shelves that could impact their stability. Future work will be dedicated to better quantifying past climate variability by combining surface mass balance and water isotope constraints and to broaden multi-model projections of the Antarctic surface mass balance.

Dr Elizabeth (Libby) Barnes is an associate professor of Atmospheric Science at Colorado State University. She joined the CSU faculty in 2013 after obtaining dual B.S. degrees (Honors) in Physics and Mathematics from the University of Minnesota, obtaining her Ph.D. in Atmospheric Science from the University of Washington, and spending a year as a NOAA Climate & Global Change Fellow at the Lamont-Doherty Earth Observatory. Professor Barnes' research is largely focused on climate variability and change and the data analysis tools used to understand it. Topics of interest include earth system predictability, jet-stream dynamics, Arctic-midlatitude connections, subseasonal-to-decadal (S2D) prediction, and data science methods for earth system research (e.g. machine learning, causal discovery). She teaches graduate courses on fundamental atmospheric dynamics and data science and statistical analysis methods. Professor Barnes is involved in a number of research community activities. In addition to being a lead of the new US CLIVAR Working Group: Emerging Data Science Tools for Climate Variability and Predictability, a funded member of the NSF AI Institute for Research on Trustworthy AI in Weather, Climate and Coastal Oceanography (AI2ES), and on the Steering Committee of the CSU Data Science Research Institute, she recently finished being the lead of the NOAA MAPP S2S Prediction Task Force (2016-2020). Dr Barnes received the AGU Turco Lectureship for 2020, AMS Clarence Leroy Meisinger Award for 2020, and was awarded an NSF CAREER grant in 2018. She received the George T. Abell Outstanding Early-Career Faculty Award in 2016 and was recognized for her teaching and mentoring by being awarded an Honorable Mention for the CSU Graduate Advising and Mentorship Award in 2017 and being named the Outstanding Professor of the Year Award in 2016 by the graduate students of the Department of Atmospheric Science. In 2014 she was the recipient of an AGU James R. Holton Junior Scientist Award.

Explainable Neural Networks for Advancing Scientific Discovery

Recent advances in machine learning have yielded many breakthroughs in commercial applications, and these techniques hold enormous promise for scientific discovery. While exciting advances with these tools have already been seen in other scientific disciplines, e.g. life sciences, they have been more slowly embraced by the geoscience community. One possible explanation for this is the perceived “black box” that outputs an answer without any explanation as to “why?” or “how?”. In this talk, I will discuss how the field can make the most of machine learning interpretation techniques (i.e. “explainable AI”) to open the black box and push the bounds of scientific discovery. This has profound implications for machine learning use in science, as it not only increases trust in the output, but also allows us to learn new science from the decision making process of the algorithm itself. I will discuss applications in climate science, including subseasonal-to-decadal prediction and the earth system response to climate change.

David Bigelow (Minerva Intelligence). After studying Geological Engineering at the University of British Columbia, Dave worked as a consultant for a few years before embarking on his M.Sc. at Simon Fraser University, Canada, under the supervision of Dr Gwenn Flowers. Dave's research interests focus on the use of sensors and geophysical data to better understand glacier hydrology and the hazards posed by a changing cryosphere. Dave is currently working for Minerva Intelligence, a startup in Vancouver, Canada, applying novel cognitive AI methods to better characterize and communicate physical risks associated with climate change.

The role of englacial hydrology in the filling and drainage of an ice-dammed lake

In a time of retreating glaciers, outburst floods from ice-marginal lakes are poised to become more prevalent as glaciers thin and tributaries detach. A detailed field-based investigation of the filling and drainage of one such lake, dammed by the 70-km-long Kaskawulsh Glacier in Yukon, Canada, was conducted to characterize the role of the little-studied englacial hydrological system during these events. We deployed a variety of geophysical and hydrometeorological instruments in and around the ~1 km^2 lake to monitor the hydrology and dynamics of the lake-glacier system. By integrating the results from all instruments and surveys, we develop a conceptual model that describes the evolution of various storage reservoirs leading up to, during and following lake drainage.
From the beginning of the instrument record in June 2017, the subaerial lake filled at an average rate of 0.5 m d^{-1} before reaching a maximum volume of 9.9x10^6 m^3 on 17 August. GPS and timelapse imagery reveal vertical glacier displacements exceeding 25 m near the ice front and 3 m at 1 km distance, as water is injected into a subglacial water wedge beneath a partially floating ice shelf. These data are used to estimate the evolution of the subglacial hydraulic potential, from which a hydraulic seal and likely flood flowpaths are delineated. Abrupt changes in ice-shelf uplift rates, associated with the formation of fractures and faulting, are linked to a redistribution of englacial water. Near the surface, water pressures in multiple boreholes exhibit sudden changes of up to 15 m of head, while at depth, ice-penetrating radar reflection-power measurements indicate fast and slow adjustments in englacial water storage. The onset of drainage begins within six days of a reversal in the subglacial hydraulic gradient near the lake, whereby flow across 55% of the lake catchment area is redirected away from the lake and toward the Kaskawulsh Glacier. Lake outflow discharge appears to increase exponentially over the course of ~19 days, before reaching an estimated maximum of 75-110 m^3 s^{-1} on 4 September. Radar data collected after the drainage event suggest that the englacial reservoir did not empty entirely, hinting at a possible buffering role for the englacial drainage system.
According to water-balance calculations, the subglacial and englacial reservoirs store approximately 55% and 22%, respectively, of the water in the catchment at peak lake level, compared to 23% in the subaerially exposed lake. In our conceptual model, the subaerial, subglacial and deep/shallow englacial reservoirs connect abruptly in a series of hydromechanical events detected across multiple sensor types. The dynamic coupling of these reservoirs and the abrupt nature of connections between them represent an advance in our conceptual understanding of outburst floods from ice-marginal lakes.

Dr Paolo Cipollini is an engineer and Satellite Oceanographer with the European Space Agency at ESA-ESTEC in the Netherlands. After his MEng (Electronics) and PhD in Environmental Monitoring with the Universities of Pisa and Florence in Italy, Paolo spent a large part of his career at the National Oceanography Centre in Southampton, UK, studying ocean processes such as planetary waves by a host of remotely sensing data, with particular focus on satellite radar altimetry which he also contributed to develop in the coastal zone (coastal altimetry). More recently, he worked for the ESA Climate Office on development and exploitation of Climate Data records of Essential Climate Variables over the Oceans. In his current post as Ocean and Ice Senior Scientist with the Earth & Mission Science Division of ESA-ESTEC, Paolo supports the development and implementation of ESA's future missions for oceanography and cryospheric science.

Essential Climate Variables over Oceans and Ice: a View from Space

Satellite remote sensing enables the determination of many geophysical parameters from space, including more than 20 Essential Climate Variables (ECVs) defined by the Global Climate Observing System. These are key geophysical quantities (for instance: Sea Surface Temperature or Soil Moisture) that describe the state of the earth's climate system, and whose long-term, sustained monitoring is essential for understanding climate evolution. To respond to user needs for Earth Observation data for Climate Research, the European Space Agency has established since 2010 the Climate Change Initiative (CCI), an R&D programme which aims to realise the full potential of the long-term global Earth Observation archives that ESA and other space agencies have established over the past 30 years, as a significant and timely contribution to the ECV databases required by UNFCCC. In this talk we will illustrate the defining features of the CCI programme, such as the focus on quality control and full quantification of the uncertainty in the products, which maximise their usefulness for the climate modelling community. We will then present the main scientific results already enabled by the CCI ECVs, with several examples over the oceans and the cryosphere.

Dr Ruzica Dadic is a Senior Research Fellow at Victoria University of Wellington’s Antarctic Research Centre in Wellington, New Zealand. She joined the Antarctic Reseach Centre in 2010, after obtaining her PhD at the ETH Zürich, in collaboration with the WSL Institute for Snow and Avalanche Research SLF, in Davos, Switzerland. Before coming to Wellington, Dr Dadic did a Postdoc at the University of Washington in Seattle. Her research focus is on physical processes in snow/ice-atmosphere interactions and their influence on the energy and mass balance of cold regions, including the subsequent effects on ice core records, sea ice evolution and sea-level rise. Her current projects include studying snow processes on sea ice, air bubbles in ice cores and glacier mass balance in Alpine regions.

Spatial variability of the sea ice surface (SSL/snow) during MOSAiC

Snow cover dominates the thermal and optical properties of sea ice and the energy fluxes between the ocean and the atmosphere, yet data on the physical properties of snow and its effects on sea ice are limited. This lack of data leads to two significant problems: 1) significant biases in model representations of the sea ice cover and the processes that drive it, and 2) large uncertainties in how sea ice influences the global energy budget and the coupling of climate feedback. The MOSAiC research initiative enabled the most extensive data collection of snow and surface scattering layer (SSL) properties over sea ice to date. The ultimate goal of our measurements is to determine the spatial distribution of physical properties of the surface layer of sea ice. Here we will present multi-scale (microscale to 100-m scale) measurements of the surface layer (snow/SSL) over sea ice. Here, we will present data from leg 5 of the MOSAiC expedition, where the surface layer changed from the surface scattering layer, characteristic for the melt season, to an early autumn snow pack, including rain on snow events. The structural properties of this transition period are poorly documented, and this season is critical for the initialization of sea ice and snow models. Furthermore, these data are crucial to interpret simultaneous observations of surface energy fluxes, surface optical and remote sensing data (microwave signals in particular), near-surface biochemical activity, and to understand the sea ice processes that occur as the sea ice transitions from melting to freezing.

Matthew England is Scientia Professor of Ocean and Climate Dynamics at the University of New South Wales, Australia. He is a Fellow of the Australian Academy of Science and a Fellow of the American Geophysical Union. Matthew's research explores large-scale ocean circulation and its influence on regional and global climate, with a particular focus on the Southern Hemisphere. Using ocean and coupled climate models in combination with observations, he studies how ocean currents affect climate and climate variability on time scales of seasons to centuries. His work has made significant impact on the treatment of water-masses in models, on our understanding of large-scale Southern Hemisphere climate modes, and on the mechanisms for regional climate variability from the tropics to Antarctica.

Global ocean-atmosphere climate teleconnections

Interannual to multi-decadal climate variability across the global ocean-atmosphere system shows evidence of being interconnected across ocean basins and across hemispheres. In this talk I will outline how global ocean-atmosphere climate teleconnections link the tropics to high-latitudes, and the Southern Ocean to the North Atlantic. Each of the tropical Pacific, Atlantic and Indian Oceans interacts with adjacent ocean basins as well as teleconnecting to polar latitudes. Via propagating planetary waves in the ocean, the Southern Hemisphere can trigger changes in the North Atlantic on multi-year time-scales, and in turn, the North Atlantic overturning circulation can alter the location of the ITCZ, the strength of the Walker Circulation, and the atmospheric circulation in the Amundsen Sea.

Jessica Fitzsimmons (Texas A&M University) is a classically trained chemist who transitioned into chemical oceanography as a way to apply her chemical skills to understanding the natural ocean environment. She got her Bachelor's degree in Chemistry and Biology with a concentration in Marine Science at Boston University in 2008 and then pursued oceanographic graduate research at MIT in the MIT/Woods Hole Oceanographic Joint Program, earning her PhD in Chemical Oceanography in 2013. Thereafter she was a postdoctoral scholar at both MIT and the Institute for Marine and Coastal Sciences at Rutgers University. She started as an Assistant Professor in the Department of Oceanography at Texas A&M University in 2015 and was promoted to Associate Professor with tenure in 2020. In 2019 she was awarded an Early Career Fellow by the National Academy of Science's Gulf Research Program. She has over 40 peer-reviewed publications and has sailed on 21 oceanographic research cruises for over a year of logged days at sea. Her primary research interests are in the marine biogeochemistry of micronutrient trace metals, their speciation, and their isotopes, specifically Fe, Mn, Zn, Cu Cd, and Ni, which she measures using ICP-MS analytical techniques. She is proud to be a Co-Chief Scientist of the next U.S. GEOTRACES GP17-OCE cruise to the South Pacific and Southern Oceans, as part of the International GEOTRACES Programme.

Micronutrient trace metal dynamics in the Arctic Ocean

The Arctic Ocean is the smallest and shallowest ocean on the planet, and it is also unique in its large continental shelf area, significant riverine inputs, perennial sea ice coverage, and limited exchange with other ocean basins. In addition to these distinctions, it is also disproportionately affected by ongoing climate change, suffering increased temperatures, precipitation, permafrost melt, and riverine fluxes. All of these effects trickle down to the Arctic ecosystem, causing changes to stratification, nutrient supply, and resulting biological community composition. Here, I will review the cycling of trace metal micronutrients in the Arctic Ocean, using new data from the International GEOTRACES Program. Micronutrient trace metal profiles are very different in the Arctic than in the rest of the global ocean, and I will review the mechanisms behind these trends. Together, these new data help us to predict how trace metal micronutrients may play a role in the biogeochemistry of a future altered Arctic Ocean.

Markus Frey is a senior atmospheric and ice chemist at the British Antarctic Survey, Cambridge, UK since 2008. He got his PhD in Hydrology and Atmospheric Sciences at the University of Arizona in 2005. His research is about physical and chemical air-snow exchange processes to understand how snow and ice surfaces influence atmospheric composition and oxidation capacity, and ultimately climate, with a focus on tropospheric ozone, the nitrogen and sulphur cycle, halogen chemistry, as well as aerosol formation and growth. To date he has lead 15 atmospheric sampling and ice coring projects on expeditions to the Poles and the Bolivian Andes, including three sea ice cruises during winter.

Sea salt aerosol from blowing snow above sea ice – observations, modelling and atmospheric impacts

Recent field campaigns provide evidence of a hypothesised source of sea salt aerosol (SSA) from blowing snow (BSn) above sea ice, which can account for SSA winter/spring time maxima observed in the polar regions. SSA is a major background aerosol, contributing directly and indirectly, via formation of clouds, to regional climate, and one of the drivers of tropospheric ozone depletion in polar spring through the release of reactive halogens. Research cruises in the Antarctic and Arctic pack ice allowed for in situ observations in the region of the hypothesised BSn source during a time of year when it is most active. Coarse sea salt aerosol (0.3-6 micrometer) concentrations were found to be increased during and after blowing snow events. Mass budget estimates show that snow on sea ice contains even at low salinity (< 0.1 psu) more than enough sea salt if released by sublimation to account for observed SSA increases. In the Antarctic SSA fractionation in sulphate with respect to sea water allowed attributipon of >90% SSA mass to the BSn source, whereas in the Arctic anthropogenic sulphate pollution requires the use of other chemical tracers to constrain source contributions. Here we'll give an overview of surface measurements in the Antarctic and Arctic, most recently on MOSAiC, updates on the model parameterisation and discuss potential implications for tropospheric composition, including halogens, and climate.

Phil Hwang is a Reader in Geography at the University of Huddersfield, UK. He was awarded a PhD from the University of Manitoba in Canada, researching remote sensing of Arctic sea ice. Since his first Arctic expedition in 2003, he has participated in more than 10 Arctic expeditions. Following the completion of his PhD, his research has been extensively funded by UK NERC, EU, and the U.S.A. ONR to gain a better understanding of rapidly changing Arctic sea ice and environments. He was the lead author of the 2020 MCCIP report card on Arctic sea ice. His current Earth Observation research includes studying environmental changes and impacts occurring in the Arctic and African countries.

Satellite observation of the floe size distribution of Arctic sea ice: implications for sea ice models

The marginal ice zone in the Arctic Ocean is an area of low ice concentration that consists of discrete sea ice floes of various sizes. Over the past decades, this marginal ice zone has expanded and is projected to expand to an even greater extent in the future. However, existing sea ice-ocean/climate models oversimplify the marginal ice zone processes, especially floe breakup and size-related processes. In this talk, I present the analysis of satellite-derived sea ice floe size data collected across the Arctic Ocean to investigate spatial and temporal characteristics of the floe size distributions. This new observational data set is used to diagnose the most recent sea ice models and inform discussions for the improvement or development of new model physics and parameterisations.

Giulia Mazzotti is a PostDoc in the Snow Hydrology group at the WSL Institute for Snow and Avalanche Research SLF in Davos, Switzerland. She holds a MSc degree in Environmental Engineering from ETH Zurich and conducted her PhD research on forest snow process dynamics at SLF and ETH. In her current position within the operational snow-hydrological modelling team, she contributes to issuing its products and to the continued development of its modelling framework.

Forest snow modelling from tree to regional scales

Forest snow cover dynamics affect hydrological regimes, ecosystems, and climate feedbacks. Processes shaping forest snow cover evolution thus need to be captured by models that operate across a wide range of spatial scales. Yet, the heterogeneous structure of forest canopies causes strong small-scale variability of canopy-snow interactions, which creates a major challenge for coarse-resolution models intended for larger-scale applications. This talk will present our research path from forest snow process observations at the tree scale to their representation in coarse-resolution models. We designed mobile multi-sensor platforms to capture small-scale process variability and its relationship to canopy structure. The resulting spatially distributed datasets allowed us to verify the capability of the hyper-resolution model FSM2 to capture forest snow process dynamics at the meter scale. We then compared results from hyper-resolution simulations to spatially lumped, coarse-resolution simulations. Based on these model upscaling experiments, we could derive recommendations for modelling forest snow processes in medium- to large-scale applications. Current efforts to integrate improved process representation into Switzerland's operational snow-hydrological modelling framework will be outlined.

Dr Jenny Mecking (National Ocenaography Centre) completed her BMath at the University of Waterloo in Waterloo, Ontario, Canada studying Honours Scientific Computation/Applied Math, where she started to develop her interests in ocean and climate modelling. This motivated her move to Dalhousie University in Halifax, Nova Scotia, Canada to do a MSc in Oceanography, supervised by Profs Richard Greatbatch and Jinyu Sheng. She then moved on to Kiel, Germany where she completed her doctorate in natural sciences at GEOMAR in 2013 supervised by Profs Noel Keenlyside and Richard Greatbatch investigating North Atlantic Multidecadal Variability. She moved on to her first post-doc in the Physical Oceanography at the University of Southampton in Southampton UK. Since 2019 she has been working as an Ocean/Climate Scientist at the National Oceanography Centre in Southampton, UK in the Marine Systems Modelling group. Her research mainly focuses on the North Atlantic using global coupled climate models to investigate extreme events on seasonal timescales to climate scale changes.

Predicting the 2015 North Atlantic Cold Blob and European Heat Wave

In 2015 the eastern North Atlantic subpolar gyre had record cold conditions while globally it was the warmest year on record at that time. Observation based studies have found evidence that these SST anomalies can be linked to the heat wave experienced over Europe that summer. In the years following the cold blob the temperatures remain anomalously cold, as well as anomalously fresh in the upper layers of the eastern North Atlantic Subpolar gyre. Therefore, being able to predict the development, enhancement and persistence of such an anomaly is essential for good seasonal and longer predictions. At present modelling systems have had difficulties in simulating/maintaining the 2015 cold blob. In this work we apply a novel initialization technique using anomalous initialization from a forced ocean simulation to simulate the 2015 heat wave. The anomalous initialization technique was successful in re-forecasting the 2015 heat wave when initialized from May 1, 2015. To successfully model the heat wave the atmosphere, ocean and sea ice initial conditions have to work together well. This technique was then used again to study the 2015 cold blob initialized from November 1, 2014. A thing to note is that the winter of 2014/15 had a persistent positive NAO which led to a strengthening of the already cold North Atlantic SPG. Our experiments do capture a further reduction in heat content (often at the same time as a persistent positive NAO) in the cold blob region. However, the timing is off and typically 2-3 years too late (i.e. 2017 or 2018 and not 2015). This result suggests that the anomalous ocean conditions do not force a deterministic NAO response, affect the likelihood of occurrence of extreme NAO events.

Dr Joellen Russell is an oceanographer, climate scientist and University Distinguished Professor at the University of Arizona. Professor Russell's research uses robot floats, supercomputers and satellites to observe and predict the ocean's role in the climate and carbon cycle of the past, the present and the future. Professor Russell is the lead for the modeling theme of the Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM) including its Southern Ocean Model Intercomparison Project (SOMIP). She currently serves as Co-Chair of the NOAA Science Advisory Board's Climate Working Group and on the National Center for Atmospheric Research's Community Earth System Model Advisory Board. Professor Russell is one of the 14 scientists behind an amicus curiae brief supporting the plaintiff in the historic 2007 U.S. Supreme Court decision on carbon dioxide emissions and climate change, Commonwealth of Massachusetts, et al. v. U.S. Environmental Protection Agency. Before joining UA, Dr Russell was a Research Scientist at Princeton University and the National Ocean and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory (NOAA/GFDL). She received her A.B. in Environmental Geoscience from Harvard and her PhD in Oceanography from Scripps Institution of Oceanography, University of California, San Diego. You can follow her on Twitter at @deepblueseanext.

Designing the Required Southern Ocean Observing System for Predicting Climate Change: Robot Floats, Satellites and Supercomputers

The Southern Ocean is the windiest place in the world, with frequent intense storms. The winds in these storms deepen the mixed layer and drive large fluxes of carbon and heat between the ocean and the atmosphere. Unfortunately, these fluxes cannot be observed directly from space; we rely on vector wind measurements and in situ ship and float-based observations to determine them. Our space-based observing network, however, only captures the vector winds over the Southern Ocean twice per day at best. We need more frequent vector winds to ensure that the wind fields in the climate reanalyses we use are accurate. Our estimates of the Southern Ocean air-sea carbon fluxes, based on these reanalysis winds, are uncertain and about 50% of the global uncertainty in air-sea carbon exchange is associated with the Southern Ocean. We show that higher winds are consistent with increased outgassing and reduced net uptake of atmospheric carbon by the Southern Ocean. We describe our observing system design experiment to determine the best additional scatterometer to add to the wind-observing constellation to capture more of the high winds and reduce the uncertainty in the Southern Ocean carbon budget.

Doug Smith has worked at the UK Met Office since 1997. He developed the Met Office decadal prediction and demonstrated improved skill through initialisation with observations. He currently researches the predictability of climate on seasonal to decadal timescales, with particular interests in the physical mechanisms and whether models underestimate predictable signals. He co-chairs the Polar Amplification Model Intercomparison Project (PAMIP) and helped develop the protocol for coordinated experiments to assess the causes and consequences of polar amplification.

Robust but weak multi-model atmospheric response to future Arctic sea ice loss

The possibility that Arctic sea ice loss could weaken mid-latitude westerlies and promote more severe cold winters has sparked more than a decade of scientific debate, with apparent support from observations but inconclusive modelling evidence. Here we analyse a large multi-model ensemble of coordinated experiments from the Polar Amplification Model Intercomparison Project (PAMIP) and find that all models simulate a weakening and equatorward shift of tropospheric winds, but the stratospheric response is not robust. We elucidate the physical mechanism and develop a potential constraint on the real-world response based on eddy momentum feedback. Observed relationships have weakened recently and are no longer inconsistent with the models. However, the modelled response to Arctic sea ice is weak: the North Atlantic Oscillation response is similar in magnitude and opposite in sign to the projected response to increased greenhouse gases, but would only account for around 10% of the interannual variability.

Laura Stevens (University of Oxford)
Stress coupling between Greenland supraglacial lakes during rapid drainage

Pepijn Veefkind is a senior scientist at the Royal Netherlands Meteorological Institute (KNMI), in the field of satellite remote sensing of the atmosphere. He is also affiliated with the Delft University of Technology. Pepijn studied physics and meteorology at Utrecht University, from which he also earned a PhD degree on research of satellite remote sensing of aerosols. As the principal investigator of the Tropospheric Monitoring Instrument (TROPOMI), and the deputy principal investigator of the Ozone Monitoring Instrument (OMI), Pepijn is working on leading projects for observing atmospheric composition from space. At KNMI he is leading the OMI/TROPOMI cluster in the R&D Satellite Observations department. He is an active member of the atmospheric composition remote sensing community and served on several advisory groups and committees. He has been involved in more than 100 peer reviewed publications in scientific journals as author or co-author.

The Impact of COVID-19 Policy Measures on Air Quality and Climate: The View from Space

Policy measures to limit the spread of the coronavirus have led worldwide to reduced emissions of air pollutants like nitrogen dioxide (NO_2). These reductions are linked to reduced traffic and industrial production caused by lockdown measures. The Tropospheric Monitoring Instrument (Tropomi) on board the EU Sentinel 5 Precursor satellite is providing accurate and timely concentration data for several trace gases. While Tropomi NO_2 data have been used by leading news media worldwide to cover the impact of the COVID-19 lockdown measures on air quality, it is important to carefully analyze the data to separate the signal of the reduced emissions from variability due to the weather. Assessments of several trace gases measured by Tropomi over different regions of the world will be presented. These assessments indicate that for megacities on all continents, reductions in column amounts of tropospheric NO_2 range between 14% and 63% during lockdown periods, whereas also in other trace gases the signal is present. The analyses of NO_2 are not only relevant for quality but also for climate change, as the emissions of NO_2 and CO_2 are linked.

Thomas Wahl is an Assistant Professor for Coastal Risks and Engineering at the University of Central Florida (UCF), where he is affiliated with the Civil, Environmental, and Construction Engineering Department and the National Center for Integrated Coastal Research (UCF Coastal). He obtained a Diploma in 2007 and PhD in 2012 in Civil Engineering at the University of Siegen, Germany. Afterwards, he took a postdoc position at the College of Marine Science at the University of South Florida. Before joining UCF in 2017, he was a Marie Sklodowska-Curie Fellow of the European Union at the University of Southampton, UK. Through his research he connects engineering and various science disciplines to better understand the vulnerability of coastal societies, built infrastructure, and fragile ecosystems under climate change conditions. He studies changes in coastal sea levels (mean and extreme), tides, ocean waves, and freshwater flows and the associated impacts to support the development of adaptation strategies.

Bigger ships or less flooding? How tidal changes affect flooding along the U.S. coast

Nuisance flooding (NF) is defined as minor, nondestructive flooding that causes substantial, accumulating socio-economic impacts to coastal communities. While sea-level rise is the main driver for the observed increase in NF events in the U.S., I will show that secular changes in tides also contribute. An analysis of 40 tidal gauge records from U.S. coasts finds that at 18 locations NF increased due to tidal amplification, while decreases in tidal range suppressed NF at 11 locations.

Estuaries show the largest changes in NF attributable to tide changes, and these can often be traced to anthropogenic alterations. Limited long-term measurements from estuaries suggest that the effects of evolving tides are more widespread than the locations considered in the analysis. The total number of NF days caused by tidal changes has increased at an exponential rate since 1950, adding ~27% to the total number of NF events observed in 2019 across locations with tidal amplification.