UP 1: Oceanography and Climate Modelling

Time: Thursday 11:00–12:45 Location: H3

UP 1.1 Thu 11:00 H3

On the Serious Limitations of Current Field Measurements and Measuring Techniques for Air-Sea Gas Exchange — •Bernd Jähne — HCI am IWR, Universität Heidelberg — Institut für Umweltphysik, Universität Heidelberg

Despite half a century of field measurements of the gas transfer velocity across the air-ocean interface, it is still not possible to provide a reliable relation between the gas transfer velocity and the parameters driving the exchange process from these measurements. The basic limitations are two-fold. Firstly, the data mainly cover only medium wind speeds and show discrepancies which are not yet understood. Secondly, none of the existing field measuring techniques is really suitable for low-wind speeds. Mass balance methods suffer from the long time constants and eddy covariance measurements from too low fluxes. Active thermography does not work either, because of the need to heat a too large patch at the water surface. The floating chamber technique is not suitable at all to measure gas transfer velocity because it cuts off the wind shear at the water surface, sensible and latent heat transfer and disturbs the wind-wave field.

In consequence, novel field measuring techniques need to be invented, which avoid the disadvantages and shortcomings of the existing technique. In addition, laboratory measurements must be performed, which simulate the oceanic conditions in an appropriate way, close the fetch-gap and wave-age gap and give direct insight into the mechanisms.

UP 1.2 Thu 11:15 H3

Thermohaline circulation - the role of advection in dynamics and stability — •Leonie Neitzel and Edeltraud Gehrig — RheinMain University of Applied Science, Germany

In recent years ongoing research of climate and environmental problems reveal the importance of thermohaline circulation on climate changes. The large-scale ocean circulation is driven by density gradients created by global surface salinity and temperature distributions. It can be modelled with box-models for the polar and equatorial regions of the earth. The boxes are coupled by deep water currents and surface currents that, in turn, depend on the parameter values of salinity and temperature. The dynamic system represented by the boxes and the currents typically exhibits a characteristic dynamics including e.g. bifurcations revealing critical regimes and consequently abrupt changes in the climate. In our approach we couple the model quations to an advection equation describing the changes in the density distribution within a box. This allows to investigate the role of local density changes induced by e.g. environmental influences or pollution. Our results demonstrate that local density changes created by e.g. an initial perturbation enter the thermohaline circulation via the currents and additionally affect the dynamics and stability of the system. Our comparative study of selected box models (Stommel, Marotzke and Welander model) reveals an influence of the dynamics on advective processes as well as dependencies on parameters and model approach.

UP 1.3 Thu 11:30 H3

Horizontal Wave Number Spectra in the Upper Ocean — •Jan Eric Stiehler, Christian Mertens, and Maren Walter — Institut of Environmental Physics, University of Bremen

Even though the spectra of motions in the atmosphere are well known, the same does not hold for the ocean. This has a quite simple reason: velocity measurements in the atmosphere are way more available compared to ocean current measurements as a result of the large amount of airplanes. Resolving temporal and spacial time scales is also easier in the atmosphere due to planes being able to cover much greater areas in the same time compared to ship based measurements. Those motions can be divided into a horizontally rotational part which corresponds to vortex motions in geostrophic balance and a divergent part which resembles internal gravity waves. This is accomplished by calculating and decomposing the spectra of measured shipboard underway ocean current velocity sections and velocity data from a gravity wave resolving ocean general circulation model. The shapes of the resulting model spectra compare well to the observational spectra even though they have approximately an order of magnitude less energy. Both roughly follow a k^{-3} power law at scales of 50 km to 200 km and k^{-2} at scales larger than 200 km. The results will also be used to look further into the limits of applicability of this method.

UP 1.4 Thu 11:45 H3

A Virtual Field Campaign along the MOSAiC track — •Rajka Juhrbandt[1], Suvarchal K. Cheedela[1], Nikolay Koldunov[1,2], and Thomas Jung[1,3] — [1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Bremerhaven, Germany — [2]MARUM - Center for Marine Environmental Sciences, Bremen, Germany — [3]Institute of Environmental Physics, University of Bremen, Bremen, Germany

The recently completed Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) can serve as reference to evaluate current and future ocean state of the Arctic Ocean. With this premise, we perform a virtual MOSAiC expedition in historical and ssp370-scenario experiments in data generated by CMIP6 models. Results for other paths are presented additionally.

The timespan covered ranges from preindustrial times (1851-1860) through present-day up to a 4K world (2091-2100). Preliminary results using AWI-CM model suggest that for scenario simulations a thinning of the colder surface layer and a warming of the layer between 200 and 1200 m along the MOSAiC path can be expected, while there is no significant change in temperature below this depth.

The Python-centric tool used for the analysis simplifies preprocessing of a pool of CMIP6 data and selecting data on space-time trajectory. It exposes an interface that is agnostic to underlying model or its grid type. The tool's ease of use is presented to demonstrate the potential for similar virtual field campaigns using past observations and arbitrary trajectories

UP 1.5 Thu 12:00 H3

Arctic amplification: The role of moisture — •Felix Pithan — Alfred Wegener institute, Helmholtz Centre for Polar and Marine research, Bremerhaven

Global climate change is amplified in the Arctic mostly because of the surface albedo feedback and the stable stratification of the Arctic (wintertime) lower troposphere trapping most warming near the surface. While the water vapour feedback is much stronger at low than high latitudes, moist processes do have important implications for Arctic climate and climate change which will be discussed in this presentation. Much of the wintertime transport of moisture into the Arctic occurs in discrete intrusion events that substantially alter atmospheric profiles and the surface energy budget. Weather and climate models struggle to represent the air-mass transformations associated with such intrusions, causing important biases in temperature structures and surface fluxes. In a warmer climate, the amount of latent heat convergence in the Arctic increases at the expense of dry energy convergence. The corresponding increase in precipitation is substantially stronger than in the global mean, even when normalized by the regional warming. Improving the understanding and model representation of moist processes in the Arctic is necessary to better constrain projections of future Arctic warming and the associated sea-level rise and sea-ice retreat.

UP 1.6 Thu 12:15 H3

Water tracers in the general circulation model of intermediate complexity PlaSim — •Oliver Mehling[1], Elisa Ziegler[1], Heather Andres[2], Frank Lunkeit[3], Martin Werner[4], and Kira Rehfeld[1] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]Memorial University of Newfoundland, St. John's, NL, Canada — [3]CEN, Institute of Meteorology, University of Hamburg, Germany — [4]Alfred Wegener Institute, Bremerhaven, Germany

Atmospheric water tracers provide a powerful tool to examine source-sink relations of water vapor in atmospheric general circulation models (GCMs). In particular, they offer insight into the variability of moisture transport and sources of precipitation. However, water tracers are computationally expensive, and allow only for short simulations or a small number of tracers in state-of-the-art models.

Here, we present the implementation of water tracers in a GCM of intermediate complexity, the Planet Simulator (PlaSim), which permits for millennial-length simulations with water tracers. We first show that the model can reproduce present-day precipitation patterns reasonably after tuning, and discuss the validation and remaining biases of the tracer-enabled model.

The water tracer framework is then applied to study moisture export from the Arctic in idealized experiments of warm and cold climate states using simulations forced by sea surface temperatures and sea ice concentrations from comprehensive Earth system models. We discuss the contributions of moisture evaporated in the Arctic to precipitation at high latitudes, both in the mean state and during extreme events.

UP 1.7 Thu 12:30 H3

Bayesian parameter estimation for EBMs: What can we learn about climate variability? — •Maybritt Schillinger[1,2], Beatrice Ellerhoff[1], Kira Rehfeld[1], and Robert Scheichl[2] — [1]Institute of Environmental Physics, INF 229 — [2]Institute of Applied Mathematics, INF 205, 69120 Heidelberg, Germany

Reliable climate projections in the face of global warming require an improved understanding of the internally-generated and externally-forced variability of Earth's climate. To this end, energy balance models (EBMs) provide a conceptual tool for studying climate dynamics. However, EBMs are typically based on a set of parameters with considerable uncertainties across empirical data and model hierarchies. To incorporate these uncertainties, we describe the global mean temperature as an inverse problem: We model the observed data as a function of the unknown parameters, given through the EBM's solution, and stochastic noise, representing the internal variability. With a Bayesian approach and a MCMC algorithm, we estimate the parameters as well as the best model fit to the data. In particular, we investigate how this estimate depends on the strength of internal variability compared to the response to external forcing. We discuss results for the zero-dimensional linear EBM and possible extensions with time-dependent feedback parameters. Our approach represents an application of state-of-the-art analytical and numerical techniques to the complex dynamics of Earth's climate. It can help to elaborate the potential, but also limitations, of the inverse problems approach and be readily applied to other dynamical systems with uncertain parameters.