solas

Open Science Conference

7th - 10th May 2012

Cle Elum, Washington State, USA

Edited by Kath Mortimer, Stefan Kontradowitz and Susanna Pakkasmaa
Designed by Kath Mortimer

www.solas-int.org

Surface Ocean-Lower Atmosphere Study

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Contents

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SOLAS introduction

SOLAS (Surface Ocean – Lower Atmosphere Study) is an international research initiative that aims to understand the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and how these affect and are affected by climate and environmental change. SOLAS research contributes to an understanding of human influences on the ocean/atmosphere system. This knowledge will help reduce uncertainties in predictions of future climate and environmental quality.

SOLAS focuses on the atmospheric and upper-ocean boundary layers and the air/sea interface that connects them, with research spanning the world oceans, including coastal and ice covered regions. A fundamental characteristic of SOLAS science is that requires close collaboration between scientists from many disciplines, such as oceanography, ecology, biogeochemistry, physics, chemistry, and atmospheric sciences. This conference presents the results of these collaborations and aims to encourage further work in this direction.

SOLAS projects can be divided into three focus areas:
Focus 1: Biogeochemical interactions and feedbacks between the ocean and the atmosphere
Focus 2: Exchange processes at the air-sea interface and the role of transport and transformation in the atmospheric and oceanic boundary layers
Focus 3: Air-sea flux of CO2 and other long-lived radiatively active gases.

The 2012 Open Science Conference covers a wide range of topics, for instance the mid-term strategy initiatives sea-ice biogeochemistry and its interactions with the atmosphere, sea-air exchange and impact of greenhouse gases, ocean-derived aerosols and atmospheric control of nutrient cycling and production.

The discussion sessions provide an interactive forum to explore new scientific initiatives and to think about the future of SOLAS. The International Council for Science's new Future Earth initiative is challenging the scientific community to address sustainability issues through collaboration between the natural and social sciences. How will the SOLAS community respond to this challenge?

SOLAS is sponsored by the Scientific Committee on Oceanic Research (SCOR), the International Geosphere-Biosphere Programme (IGBP), the World Climate Research Programme (WCRP) and the International Commission on Atmospheric Chemistry and Global Pollution (ICACGP).

The SOLAS International Project Office in Kiel is supported by GEOMAR | Helmholtz Centre for Ocean Research Kiel and German Federal Ministry of Education and Research via the SOPRAN (Surface Ocean Processes in the Anthropocene) project.

The SOLAS Nodal Project Office in Norwich is supported by the Natural Environment Research Council (NERC) and the University of East Anglia (UEA).

http://www.solas-int.org

Welcome notes

Welcome to Washington State, Suncadia, and the 2012 SOLAS Open Science Conference (OSC); the first OSC to be held in the United States.

Suncadia is located on the eastern slope of the Cascade Mountains near the small, former coal towns of Cle Elum and Roslyn, WA (combined population of ~ 2000). Cle Elum and Roslyn now serve primarily as hubs for camping and recreation. Washington State varies widely in climate from the rain forest on the western side of the Olympic Peninsula (~400 cm of precipitation per year) to the rain shadowed area east of the Cascade Mountains (annual precipitation of 15 cm per year). Suncadia sits just beyond the transition between western and eastern Washington and receives about 56 cm of precipitation per year. Temperatures during May typically are mild averaging 18°C with a monthly average precipitation amount of 55 mm. There is much to enjoy in the area this time of year including hiking, bicycling, horse back riding, and fishing. Suncadia itself offers golf, wine tasting at Swiftwater Cellars, and the spa and fitness center.

Suncadia, with its secluded and remote location, was chosen for the 2012 OSC with the intention of maximizing scientific interaction among all attendees, encouraging the sharing of knowledge, and paving the way for new research directions. It is our hope that this venue and meeting format will allow the SOLAS community to make significant progress in responding to today's environmental and societal challenges.

Enjoy the science and enjoy the surroundings!

Trish Quinn
on behalf of the Local Organizing Committee

Welcome to the 2012 SOLAS Open Science Conference. This meeting is the fifth in a series of meetings held in Germany (Damp, 2000), Canada (Halifax, 2004), China (Xiamen, 2007) and Spain (Barcelona, 2009).

These were all highly successful meetings that helped to summarize, synthesize, and stimulate SOLAS research and to build new international connections between SOLAS scientists. This meeting will highlight the research themes comprising the SOLAS Mid-Term Strategy and explore the trajectory of future changes in the oceans and atmosphere. This is great opportunity to meet new colleagues, to think about the future of SOLAS research, and to help envision new initiatives that will guide future research. The format allows for both formal presentations in plenary session, informal exchange of ideas at discussion sessions, and one-on-one discussions at posters. As in previous meetings, we expect these sessions to lead us to new research directions and activities.

On behalf of SOLAS, I would like to thank the Conference Organizing Committee (led by Trish Quinn), the SOLAS staff for their hard work, and our sponsors (IGBP, iCACGP, SCOR, and WCRP) for their support. Have a great meeting and enjoy the beautiful setting here in Cle Elum, Washington State.

Eric S. Saltzman
Chair, SOLAS Scientific Steering Committee

Conference Sponsors

The **Canadian Meteorological and Oceanographic Society (CMOS)**
The Canadian Meteorological and Oceanographic Society (CMOS) is the national society of individuals and institutions dedicated to advancing atmospheric and oceanic sciences and related environmental disciplines in Canada. CMOS began life in 1939 as the Canadian Branch of the Royal Meteorological Society. In 1967 it became independent and was known as the Canadian Meteorological Society until 1967 when it adopted its present name following an agreement with the oceanographic community. It was incorporated under the Canada Corporations Act in 1984.
www.cmos.ca

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www.esa.int

The **National Aeronautics and Space Administration's (NASA)** mission is to pioneer the future in space exploration, scientific discovery, and aeronautics research. NASA studies planet Earth from space to advance scientific understanding and meet societal needs.
www.nasa.gov

The **National Oceanic and Atmospheric Administration's (NOAA)** mission is to understand and predict changes in climate, weather, oceans, and coasts and to conserve and manage coastal and marine ecosystems and resources.
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The **National Science Foundation (NSF)** is the principle US Federal agency supporting fundamental research across all fields of science and engineering, and science and engineering education at all levels.
www.nsf.gov

The **Scientific Committee on Oceanic Research (SCOR)** facilitates international collaborations in the field of ocean science from the planning stage to the synthesis of results. SCOR provided support for scientists from developing countries to attend this conference through support from the U.S. National Science Foundation.
www.scor-int.org

Bundesministerium für Bildung und Forschung

SOPRAN (Surface Ocean Processes in Anthropocence) is funded by the German BMBF. SOPRAN involves 39 principal investigators from ten German partner institutions working in twenty five sub-projects. The sub-projects are allocated to six inter-related platforms: (1) Cape Verde/ Mauritania, (2) Equatorial Atlantic Ocean, (3) Mesocosms, (4) Aeolotron/FINO2, (5) Modelling/Data Management, and (6) Project Coordination. Field work is concentrated in the Baltic Sea (Mesocosm Experiments, FINO2) and the eastern tropical North Atlantic (Cape Verde Atmos./Ocean Observatories, Mauritanian upwelling, equatorial Atlantic Ocean).
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Sunday 6 May

14:00 Registration opens

19:00 Welcome reception (see page 48)

Monday 7 May

07:00 Registration

TIME	EVENT		ABSTRACT PAGE	VENUE
Theme: Sea-ice biogeochemistry and interactions with the atmosphere Chair: Jacqueline Stefels, The Netherlands				
08:30	Eric Saltzman Trish Quinn	Welcome speech		Rialto AB
08:45	Keynote: Caroline Leck	Could marine microorganisms prevent the observed sea ice-melt in the Arctic	12	Rialto AB
09:15	Véronique Schoemann	Sea ice as a source of bioavailable iron to the Southern Ocean	12	Rialto AB
09:35	Mónica Orellana	Sequencing of marine microgels in the high Arctic	13	Rialto AB
09:55	Anna Granfors	Sea ice as a source of halocarbons in polar oceans	13	Rialto AB
10:15	Coffee			
Theme: Long-lived greenhouse gases: sea-air exchange and impact Chair: Arne Körtzinger, Germany				
11:00	Keynote: Yukihiro Nojiri	Basin scale analysis of oceanic pCO_2 variability and results of atmospheric tracers for ocean CO_2 sink variability	14	Rialto AB
11:30	Dorothee Bakker	Long-lived greenhouse gases air-sea exchange and impact	14	Rialto AB
11:50	Annette Kock	Effects of surfactants on N_2O emissions from biologically productive regions	15	Rialto AB
12:10	Christoph Heinze	Changes in carbon uptake and emissions by oceans in a changing climate - CARBOCHANGE	15	Rialto AB
12:30	Extended lunch / Networking time			
16:00	Parallel discussion sessions			
	Roland von Glasow Eric Saltzman	Climate impact of seasalt-derived Cl atoms	28	Owens A
	Nadja Steiner Clara Deal	Improving our understanding of and capacity for model projections of sea ice-ocean biogeochemistry	28	Owens B
	Christoph Garbe	Parameterising k with parameters other than wind speed?	29	RialtoA
17:30	Break			
18:00	Dinner			
20:00	Poster Session	Air-sea gas exchange The carbon cycle		Poster tent
22:00	End			

Tuesday 8 May

TIME	EVENT		ABSTRACT PAGE	VENUE
Theme: Ocean-derived aerosols: production, evolution and impacts Chair: David Kieber, USA				
08:45	Keynote: Maria Cristina Facchini	Submicron marine organic aerosols: primary vs. secondary	16	Rialto AB
09:15	Elizabeth Minor	Analyzing water soluble and water insoluble organic matter: insights from lake and ocean water-column work?	16	Rialto AB
09:35	Ilan Koren	On the deep relationship between clouds and maritime aerosol	17	Rialto AB
09:55	Rainer Volkamer	Controls from a widespread surface ocean organic microlayer on atmospheric oxidative capacity	17	Rialto AB
10:15	Coffee			
Theme: Physics of air-sea exchange Chair: Rik Wanninkhof, USA				
11:00	Keynote: Carol-Anne Clayson	Recent developments in the physics of air-sea exchanges	18	Rialto AB
11:30	Christoph Garbe	Small scale transport processes at the air-water interface	18	Rialto AB
11:50	Mingxi Yang	Physical drivers in air-sea exchange of trace gases	19	Rialto AB
12:10	Wade McGillis	Sea Ice Gas Exchange Studies [2007 - 2012]	19	Rialto AB
12:30	Extended lunch / Networking time			
14:30	Plenary discussion session			
	SOLAS Scientific Steering Committee	Where we've been, where we are, where we're going, and why we matter: the SOLAS science plan and its relevance to society	30	Rialto AB
15:30	Break			
16:00	Parallel discussion sessions			
	David Kieber Lynn Russell	Ocean-derived aerosol: Properties and climate impacts	30	Owens A
	Rik Wanninkhof William Asher	Gas transfer at high wind speeds: Recent observations and constraints	31	Owens B
	Christoph Heinze Yukihiro Nojiri	Detection and monitoring large-scale impacts of ocean acidification	31	Miller
17:30	Break			
18:00	Dinner			
20:00	Poster Session	Ocean derived aerosols Dimethylsulphide Halogens		Poster tent
22:00	End			

Programme

Wednesday 9 May

TIME	EVENT		ABSTRACT PAGE	VENUE
Theme: Atmospheric control of nutrient cycling and production in the surface ocean Chair: Cécile Guieu, France				
08:45	Keynote: Emilio Marañón	Effects of atmospheric nutrient deposition on the surface ocean's biology: community structure, metabolic rates, and biogeochemical fluxes	20	Rialto AB
09:15	Huiwang Gao	Correlation of Asian dust with chlorophyll and primary productivity in the North Pacific Ocean	20	Rialto AB
09:35	Mark Moore	Atmospheric iron inputs and the sub-tropical Atlantic biogeochemical divide	21	Rialto AB
09:55	Tim Jickells	Atmospheric nutrient inputs to the western Pacific	21	Rialto AB
10:15	Coffee			
Theme: SOLAS and the future ocean (short talks and panel) Chair: Douglas Wallace, Canada				
11:00	Scott Doney	Rising atmospheric CO_2 and ocean acidification	22	Rialto AB
11:20	Cliff Law	Understanding how multiple anthropogenic stressors will alter ocean biogeochemistry	22	Rialto AB
11:40	Panel discussion			Rialto AB
12:30	Extended lunch / Networking time			
15:00	Parallel discussion sessions			
	Christoph Garbe Véronique Garçon David Woolf	Earth observations for SOLAS science	32	Owens A
	Jacqueline Stefels Rafel Simó	Potential shifts in DMS flux from the ocean due to a changing climate	32	Owens B
	Roberta Hamme, Remi Losno, I-I Lin, Diego Gaiero	Impacts of dust and ash on ocean productivity	33	Miller
16:30	Break			
17:00	Poster Session	Aeolian input Biogeochemistry Long-lived greenhouse gases Oxygen Minimum Zone systems		Poster tent
19:30	Conference Banquet			
23:30	End			

Thursday 10 May

TIME	EVENT		ABSTRACT PAGE	VENUE
Theme: Air-sea gas fluxes at eastern boundary upwelling and oxygen minimum zone (OMZ) systems Chair: Véronique Garçon, France				
08:45	Keynote: Andreas Oschlies	Sorting out possible scenarios about the future of oxygen minimum zone systems	24	Rialto AB
09:15	Sophie Bonnet	Dinitrogen fixation above oxygen minimum zones	24	Rialto AB
09:35	Damodar M Shenoy	Cycling of nitrous oxide, methane and dimethylsulphide at the Candolim time series station in the Arabian Sea	25	Rialto AB
09:55	José Martín Hernández-Ayón	Influence of the subtropical OMZ in the inorganic carbon along the pacific Mexican coast	25	Rialto AB
10:15	Coffee			
Theme: Emerging Issues Chair: Eric Saltzman, USA				
11:00	Michio Aoyama	Budgets and distribution of ^{137}Cs and ^{134}Cs in the North Pacific Ocean: impacts of global fallout, Chernobyl and Fukushima NPP accidents	26	Rialto AB
11:20	Xiaohong Yao	Which factors determine spring biological bloom in the China Sea?	26	Rialto AB
11:40	Roberta Hamme	Iron fertilization by volcanic ash: Implications for ocean carbon uptake	27	Rialto AB
12:00	Lihini Aluwihare	New developments in the field of marine organic matter composition and cycling	27	Rialto AB
12:20	Closing remarks			Rialto AB
12:30	Extended lunch / Networking time			
14:00	End			

Intro

Plenary talks

Theme: Sea-ice biogeochemistry and interactions with the atmosphere

Could marine microorganisms prevent the observed sea ice-melt in the Arctic?

Caroline Leck (keynote speaker)
Department of Meteorology, Stockholm University, Sweden

In the Arctic we see signs of a variability suggesting that the future may be different from the present, being intimately linked to global climate and to the Earth's biogeochemical cycles. Polar regions are the primary global heat sinks and the Arctic and its sea ice are major elements in the global climate system. However, there is not yet a clear understanding of the strong feedback mechanisms within the Arctic climate system involving ice, low-altitude clouds, and radiation that is adequate to predict changes in the system under anthropogenic forcing.

Low-altitude clouds are the most important factor determining the melting of the sea ice in the Arctic. In particular during late summer when the albedo of the sea ice is at minimum, cloud-albedo could control the timing of the autumn freeze-up. An earlier freeze-up would lead to thicker ice and ultimately more multi-year ice the following years. Such a scenario would then constitute an overall negative feedback mechanism delaying – or even preventing – the observed sea ice-melt during the Arctic summer.

One proposed influence on cloud-albedo over the Arctic sea ice is that marine gels produced by ice algae and/or phytoplankton in the surface water dominate the available cloud condensation nuclei (CCN) population. But do marine gels predominately control the cloud droplets and thus the optical properties of the clouds? Could there be other biological controls on the formation of the cloud over the Arctic sea ice, and if so will biological activity and production of CCN increase or decrease with melting of the ice?

Sea ice as a source of bioavailable iron to the Southern Ocean

Véronique Schoemann
Royal Netherlands Institute for Sea Research (NIOZ), Texel, The Netherlands

Iron (Fe) is an essential micronutrient. It limits primary productivity in more than 30% of the oceans, including the Southern Ocean (SO), and has a crucial impact on the biogeochemical cycles of carbon and other elements with ultimate influence on the Earth Climate system.

The SO is characterized by the presence of sea ice, extending from 3×10^6 km^2 in summer to 18×10^6 km^2 in winter and has a crucial impact on climate processes. This talk will address the potential role of sea ice as a source of bioavailable Fe, its impact on primary productivity and on the biological pump. Compiled dissolved and particulate Fe concentrations data show that Fe is 10-100 times more concentrated in pack and landfast ice than in the underlying seawater. Little variation exists between areas studied so far (e.g. Weddell, Bellingshausen Seas, East Antarctica), but strong seasonal decreases in concentrations are observed due to brine drainage during ice melt. Comparison between different sources of Fe to the photic zone of the SO shows that most of the Fe in the sea ice originates from below and that sea ice melt can deliver up to 70% of the daily Fe supply.

Micro-organisms and their derived organic matter in the sea ice could play a crucial role in the accumulation of Fe, by trapping the Fe, and also by increasing its solubility and bioavailability, e.g. uronic acids are accumulated in the sea ice and efficiently bind Fe and can favor its solubility and bioavailability.

Sea ice as a source of halocarbons in polar oceans

Anna Granfors
Department of Chemistry and Molecular Biology, University of Gothenburg, Sweden

Naturally occurring volatile halogenated organic compounds, halocarbons, are a source of halogens to the atmosphere, and can be photolyzed to form reactive halogen species, which contribute to the destruction of ozone in the polar atmosphere. Halocarbons are biologically produced in marine environments by algae and microorganisms.

Through measurements in the Arctic and Antarctic, we have found that sea ice can act as a source of halocarbons to the atmosphere in three ways. Firstly, during freezing, halocarbons were concentrated in brine and transported to the overlying air due to concentration gradients. This transport is enhanced through a gas phase transport, caused by the partitioning of halocarbons to gas bubbles trapped in the ice. Secondly, halocarbons produced by ice-living micro-organisms will add to the source strength of the ice. Thirdly, frost flowers were shown to be enriched in halocarbons, and, thus, an additional source of organo-halogens to the atmosphere.

Sequencing of marine microgels in the high Arctic

Mónica Orellana
Institute for Systems Biology, University of Washington, Seattle, Washington State, USA

Marine microgels play an important role in regulating ocean-basin-scale biogeochemical dynamics. We have recently not only found them in surface waters, but also in airborne aerosol, fog, and cloud water in the high Arctic (north of 80^{o}N), dominating the available cloud condensation nuclei number population during the summer season. These microgels have unique physicochemical characteristics and originate from organic material produced by ice algae and/or phytoplankton in the surface water. We have now sequenced the genomic material found in the microgels from the sea surface and cloud waters with next-generation sequencing technology. After the respective analysis and annotation, we found a high abundance of proteins of microbial and diatom origin, including a high number of proteins associated with antifreeze functions. Our results show the biological complexity of the origin of microgels as well as the high diversity of microorganisms found on these microgels with implications not only for cloud droplet activation but also for ice nucleation.

Plenary talks

Theme: Long-lived greenhouse gases: sea-air exchange and impact

Basin scale analysis of oceanic pCO_2 variability and results of atmospheric tracers for ocean CO_2 sink variability

Yukihiro Nojiri (keynote speaker)
Center for Global Environment Research (CGER), National Institute for Environmental Studies (NIES), Tsukuba, Ibaraki, Japan

The atmospheric pCO_2 was steadily increased or its increasing has been accelerated with the growth of fossil fuel emission during the last decade (00's), however, it is not yet known whether the globally averaged oceanic ΔpCO_2, or global net CO_2 flux between atmosphere and ocean responded with the change of increasing rate or not. The global integration effort of the in situ observation of pCO_2 covering is an important effort for the clarification of the flux variability. We are trying to analyze the basin scale pCO_2 variability in the last decade using recently developed Neural Network (NN) method with the integrated data set. The inter-annual variability of pCO_2 in some oceanic basins have been demonstrated with detailed spatio-temporal distribution, however, the decadal trend analysis of the net flux may not be appropriate, because the NN approach is good for variability analysis but not for absolute ΔpCO_2. NIES observation network includes maritime air measurement for atmospheric CO_2 with ^{13}C and O_2/N_2 ratio on board cargo ships, on which oceanic pCO_2 system installed, with a wide latitudinal coverage in the Pacific. In contrast with the heterogeneous nature of ocean surface pCO_2 phenomena, atmospheric observation can have globally averaged trends of the long-lived greenhouse gases. ^{13}C and O_2/N_2 ratio are feasible tracers for land/ocean sinks of fossil fuel carbon. Long year records of these tracers with a help of data from the ground based stations suggests an enhancement of oceanic CO_2 sink in the later half of 00's than the earlier half. Results from the atmospheric tracers will be compared with the pCO_2 variability reflecting the change in ocean physics and in the ocean biological activities.

Long-lived greenhouse gases air-sea exchange and impact

Dorothee Bakker
School of Environmental Sciences, University of East Anglia, Norwich, UK

Human activities are releasing vast quantities of the long-lived greenhouse gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the atmosphere. The oceans are absorbing about 30% of the CO_2 emissions from fossil fuel burning and cement production and are thus reducing the effects of this greenhouse gas on global climate. Net oceanic CO_2 uptake is making the oceans more acidic ('ocean acidification'), which makes it more difficult for marine calcifying organisms to build their shells. Observational records of marine CO_2 parameters are becoming longer and we are learning about variation in oceanic CO_2 uptake on increasingly long time scales of seasons, years and decades. In most regions surface water CO_2 concentrations have followed the increase in the atmospheric CO_2 content over the past few decades, with the possible exception of the Southern Ocean. The observational records may not yet be long enough to distinguish between decadal variation and long-term trends. The oceans are a major net source for atmospheric N_2O, whereas the oceanic emissions play only a minor role for the atmospheric budget of CH_4. The oceanic pathways (i.e. production and consumption) of N_2O and CH_4 are dominated by microbiological processes. Key aspects of air-sea exchange of the three gases and its impact will be discussed with an emphasis on the uncertainties and gaps in our knowledge. Assessing the long-term evolution of air-sea exchange of the long-lived greenhouse gases CO_2, CH_4 and N_2O is critical for predictions of future climate change and ocean acidification.

Effects of surfactants on N_2O emissions from biologically productive regions

Annette Kock
GEOMAR | Helmholtz Centre for Ocean Research Kiel, Marine Biogeochemistry, Kiel, Germany

Sea-to-air and diapycnal fluxes of N_2O into the mixed layer were determined in the upwelling region off Mauritania. A N_2O mixed layer budget was calculated by comparison of the regionally averaged sea-to-air and diapycnal fluxes and by quantification of the contribution of vertical advection and biological production in the mixed layer. Using common parameterizations for the gas transfer velocity, the mean sea-to-air flux is about three to four times larger than the diapycnal flux. The budget could not be closed by the contribution of vertical and horizontal advection or biological production. A balanced budget could yet be obtained by the application of a parameterization that takes into account the attenuating effect of surfactants on gas exchange. Further possible mechanisms reducing sea to air fluxes include diurnal stratification in the upper mixed layer. We will discuss the consequences of reduced N_2O emissons from biologically productive regions for global oceanic N_2O emissions.

Changes in carbon uptake and emissions by oceans in a changing climate - CARBOCHANGE

Christoph Heinze
University of Bergen, Geophysical Institute & Bjerknes Centre for Climate Research, Norway

CARBOCHANGE (endorsed by SOLAS and IMBER) is the current key European funded project on oceanic uptake of human-produced carbon dioxide. It includes 28 partners from Europe, Africa, and North America. It aims at providing the best possible process-based quantification of net ocean carbon uptake under changing climate conditions. We are improving the quantitative understanding of key biogeochemical and physical processes through combining observations and models. We upscale new process understanding to large-scale feedbacks of the ocean carbon cycle to climate change and atmospheric carbon dioxide. The most actual observations of the changing ocean carbon sink are systematically integrated with ocean carbon models and coupled Earth system models through a spectrum of data assimilation methods and advanced performance assessment tools. Results will be optimal process descriptions and realistic error margins for future ocean carbon uptake quantifications exploiting the available observational evidence. An update on recent project achievements is given.

Plenary talks

Theme: Ocean-derived aerosols: production, evolution and impacts

Submicron marine organic aerosols: primary vs. secondary

Maria Cristina Facchini (keynote speaker)
Institute of Atmospheric Sciences and Climate, Italian National Research Council (ISAC-CNR), Bologna, Italy

Particulate matter in the marine boundary layer (MBL) represents one of the most important aerosol systems at the global scale. Nevertheless the relative contribution of primary and secondary sources to the organic aerosols burden in the marine atmosphere is still controversial. A multi-technique analytical approach is used to characterize the submicron organic aerosol over the North-East Atlantic, in the absence of continental pollution plumes. Samples were collected at Mace Head throughout one year and on board of a research vessel in periods of phytoplankton bloom. The results show that submicron marine organic aerosol is a complex mixture of biogenic materials transferred from the ocean surface by the sea spray, of their conversion products due to oxidation and of gas to particle conversion involving volatile organics emitted by the marine biota. Gas to particle sources of oxalic acid and ammonium salts of dimethyl and diethyl amine (DMA+ and DEA+) will be discussed. The results indicate a secondary formation pathway for DMA+ and DEA+ representing up to 20% of secondary organic aerosol (SOA) in the North Atlantic and being the most abundant organic species detected, besides MSA. DMA+ and DEA+ formation from biogenic amines may represent an important source of marine SOA and atmospheric nitrogen at the global scale, with a seasonal cycle connected to the oceanic biological productivity, parallel to that of the organosulphur species. It will also be shown that the cloud oxidation of gaseous glyoxal, recently detected over remote oceanic regions, is an important source of submicron oxalate in the MBL.

Analyzing water soluble and water insoluble organic matter: insights from lake and ocean water-column work?

Elizabeth Minor
Large Lakes Observatory and Department of Chemistry and Biochemistry, University of Minnesota Duluth, Minnesota, USA

Understanding the sources of organic matter (OM) within marine aerosols and the mechanisms occurring to transform this OM is complicated by the difficulties in isolating and analyzing compounds within the aerosol's complex matrix of organic and inorganic species. These are challenges shared by those scientists studying water-column marine and lacustrine particulate and dissolved organic matter (POM and DOM).
This talk will summarize approaches, frustrations, and breakthroughs in current compound-class and molecular-level POM and DOM characterization. It will also discuss the overlaps in characterization techniques shared by the aerosol and water-column communities, such as FTIR and mass spectrometry approaches. Finally, it will explore similarities and differences in the chemical composition of water soluble and water-insoluble material in the aerosol and water-column environments.

On the deep relationship between clouds and maritime aerosol

Ilan Koren
Department of Environmental Sciences and Energy Research, Weizmann Institute of Science, Rehovot, Israel

Why is the estimation of aerosol effects on clouds and precipitation challenging? The answer lies within two poles: the inherent complexity of the microphysical and dynamical processes involved, and the complexity in measuring and modelling them. Scales (of space, time and wavelength) are a key component in understanding both the processes and the modelling measurements results.
There are two main "competing channels" in which aerosol can change cloud properties; the microphysical and the radiative (aerosol absorption) channels. The microphysical effect is especially relevant for marine aerosol. Aerosol, serving as cloud condensation nuclei, change the size distribution of the cloud droplets and therefore can change condensation/evaporation rates, latent heat release, collision coalescence efficiency, cloud dynamics and therefore all the derived cloud properties such as reflectance, lifetime, phase, size, and precipitation.
Marine stratocumulus decks serve as the climate coolers reflecting back to space part of the incoming solar radiation, while anvils related to deep convective clouds may warm the system by trapping part of the outgoing long wave radiation. Marine aerosol impacts these clouds in different ways that depend on clouds and aerosol types. For example wind driven sea-salt has a coarse size distribution compared to the typical submicron anthropogenic and marine-biogenic aerosol. Coarse, hydrophilic aerosol will affect clouds in ways that oppose the finer aerosol effect, and result in shortening cloud lifetime, reducing reflectivity and enhancing rain formation. The complex feedbacks will be discussed and new remote sensing and modelling results will be shown.

Controls from a widespread surface ocean organic microlayer on atmospheric oxidative capacity

Rainer Volkamer
Department of Chemistry & Biochemistry and CIRES, University of Colorado at Boulder, Colorado, USA

Organic carbon and reactive halogen species are important in the atmosphere, because they influence the reactive chemistry and lifetime of climate active gases (e.g., methane, ozone, dimethyl sulfide), and are relevant to aerosol cloud interactions. Current assessments of oxidative capacity in the marine boundary layer consider ocean sources for organic carbon primarily in context of air sea exchange of reduced hydrocarbons, primary organic aerosols, and minor amounts of organic halogen species. However, unexplained observations of elevated atmospheric glyoxal, a very soluble and short lived gas, over the remote open ocean challenge this view. This presentation summarizes results from four cruises over the tropical eastern Pacific Ocean (-22^{0}S to 22^{0}N latitude, 70^{0}W to 158^{0}W longitude; 135 days at sea) that measured marine hydrocarbons, atmospheric OVOCs (glyoxal, formaldehyde), and halogen oxide radicals (bromine oxide, iodine oxide) from the coastal to the mesotrophic and oligotrophic ocean. A major OVOC source is found to originate from dissolved organic matter (DOM) in the surface organic microlayer, which is found widespread over tropical oceans. The OVOC flux is larger than that of primary organic aerosol, and affects atmospheric oxidative capacity in terms of hydroxyl, bromine, chlorine, and interestingly also iodine radical sensitivities.

Plenary talks

Theme: Physics of air-sea exchange

Recent developments in the physics of air-sea exchanges

Carol-Anne Clayson (keynote speaker)
Physical Oceanography, Woods Hole Oceanographic Institution, Massachusetts, USA

Much progress has been made to our understanding of the processes affecting the transfer of heat, moisture, and momentum between the ocean and the atmosphere. The importance of such small-scale processes at the surface itself such as those produced by wave roughening is increasingly understood. In addition, the role of the structure of both the atmospheric and oceanic boundary layers including their stability on both our ability to understand and model the air sea fluxes has been greatly enlarged within the last few years. However, much remains unknown in both our understanding of, and our ability to accurately parameterize, such effects as the upper ocean diurnal mixed layer, sea spray, and wave effects. In this talk I will focus on advances in theories related to the parameterization of the air-sea exchanges of heat, moisture, and momentum from bulk observations, especially those aspects as related to wave processes, including the effects of sea spray and Langmuir circulation. The stable boundary layer is less well known than the unstable, and current issues and models related to both the atmospheric and oceanic stable layers and their effects on the air-sea fluxes will be highlighted in this talk. The effects of our increased understanding of these processes on flux calculations from in situ and satellite observations in both synoptic-scale weather regimes and in long-term climate analyses will be discussed. Finally, I will conclude with an overview of directions that might be useful to pursue to improve our understanding of, and ability to measure, the turbulent air-sea fluxes.

Small scale transport processes at the air-water interface

Christoph Garbe
Image Processing and Modeling, Interdisciplinary Center for Scientific Computing (IWR), University of Heidelberg, Germany

Small scale transport processes have significant impact on exchange of heat, momentum and gas across the free air water interface. When approaching the water surface, the main resistance to transport is the aqueous viscous boundary layer. Turbulences and coherent velocity structures may disrupt this boundary layer and consequently increase the transfer. Several mechanisms for generating interfacial turbulence exists, such as shear induced by wind, capillary ripples and wave breaking.
In this contribution, I will give an overview of the mechanism involved and the processes influencing them. Quantifying small-scale interactions remains challenging. Central to gaining a deeper understanding of small-scale transport processes are non-invasive imaging techniques and approaches for analyzing them. Such techniques are particle based techniques for flow measurements, concentration measurements from light induced fluorescence and thermography for resolving interfacial thermal fluctuations. Results from laboratory and field measurements will be presented. I will conclude with an outlook of connecting research in small-scale interactions with global satellite based earth observations.

Physical drivers in air-sea exchange of trace gases

Mingxi Yang
Plymouth Marine Laboratory, Plymouth, UK

The rate of air-sea gas exchange is determined by molecular diffusion and turbulent transport on both sides of the interface. Partitioning in importance of the airside vs. waterside largely depends on the gas solubility. For sparingly soluble gases such as CO_2 and SF_6, the mass boundary layer in water provides the greatest resistance to transfer.
In contrast, exchange of highly soluble or surface reactive gases, including many volatile organic compounds, is limited on the airside due to both diffusional and aerodynamic resistance.
Turbulence near the ocean surface drives gas exchange by disrupting the mass boundary layer and also increasing turbulent diffusivity. The predominant source of turbulence varies from buoyancy-driven instability under calm conditions, to wind shear in moderate seas, and potentially to wave stress in high winds. Breaking waves also lead to entrainment of air bubbles, which provide an additional pathway for air-sea exchange of sparingly soluble gases. Analogously, concomitantly formed sea spray might be important for the exchange of gases controlled on the airside.
To date, air-sea exchange observations of airside controlled trace gases are essentially non-existent. In this talk I will highlight a few empirical models of airside transfer derived from limited lab measurements of highly soluble gases and heat/water vapor exchange.
These parameterizations clearly beg for field validation, particularly for gases with near surface sources or sinks. The importance of aerodynamic resistance might be a cause for asymmetry between airside and waterside control, which challenges the simplified view of the classic 'two-layer' model.

Sea Ice Gas Exchange Studies [2007 – 2012]

Wade McGillis
Lamont-Doherty Earth Observatory, Columbia University, New York, USA

Biogeochemistry in sea-ice is controlled by, and influences, the exchange of gases. In a continuing effort to quantify processes in icy conditions, the air-water transfer of dissolved gases is measured in laboratory facilities that simulate the freezing, frozen, and physical processes in ice. Freezing surfaces undergo a significant increase in Schmidt number effecting gas exchange as in the ice-free surface ocean. During incipient freezing, ice nuclei increase local temperature and mixing. In the presence of mature sea ice, the surface area for heat and gas exchange is reduced, augmenting the effect of wind and current-driven transport. These mechanisms include changes in mixing by wind, waves, and ice; buoyancy production; brine transport; and ice-water turbulence. As in laboratory wind-wave tank experiments, new model-ice tank experiments are helping to understand key gas exchange mechanisms in icy conditions. The role of changes in gas exchange under icy conditions on biogeochemical cycles is discussed.

Plenary talks

Theme: Atmospheric control of nutrient cycling and production in the surface ocean

Effects of atmospheric nutrient deposition on the surface ocean's biology: community structure, metabolic rates, and biogeochemical fluxes.

Emilio Marañón (keynote speaker)
Departamento de Ecología y Biología Animal, Universidad de Vigo, Spain

Atmospheric deposition represents an important pathway for the supply of nutrients to the open ocean and, particularly in oligotrophic waters, has the potential to affect significantly the structure and functioning of the planktonic community. During the last decade, the effects of atmospheric deposition on the biology of the upper ocean have been investigated intensely through observational, experimental and modelling approaches. These studies have shown that the supply of nutrients from the atmosphere can result in a complex cascade of effects which can be traced at different levels of organization in the ecosystem. In terms of community structure, the effects of atmospheric deposition events seem to be more complex than previously acknowledged, as different taxonomic groups often respond differently to a given input. There is growing evidence to indicate that, in addition to the fertilising effect of atmospheric deposition through the stimulation of primary production and N_2 fixation, other metabolic rates such as bacterial production and community respiration can also be stimulated, with potential implications for CO_2 sequestration by the biological pump. Finally, spatial variability in atmospheric deposition can lead to biogeographic differences in nutrient limitation and the relative importance of key biogeochemical fluxes. This contribution aims to provide an overview of recent findings regarding the effects of atmospheric nutrient deposition on the composition, structure, metabolism and biogeochemical functioning of the upper ocean's biota.

Correlation of Asian dust with chlorophyll and primary productivity in the North Pacific Ocean

Huiwang Gao
Key Laboratory of Marine Environmental Science and Ecology, Ministry of Education, Ocean University of China, Qingdao, People's Republic of China

The deposition of atmospheric aerosols, especially mineral aerosols from arid and semi-arid areas, provides nutrients, such as nitrogen, phosphorus, Fe, to enhance primary production in oceans. Asian dust is the second largest aeolian dust source on the earth and mainly originates from the Taklimakan and Gobi deserts of Asia. 10 to >102 Tg per year of Asian dust is released to the atmosphere, accounting for 5% - 40% of the global dust loading. A few observations show that dust deposition could trigger bloom both in HNLC and LNLC waters in the Pacific Ocean, indicating that Asian dust is very important for the growth of phytoplankton from marginal seas to the open ocean. For example, the input of dust was found to play an important role in the initiation of spring blooms in the East/Japan Sea, and a high correlation existed between dust events and biological productivity in the western North Pacific. Our recent studies found that bloom frequency over the whole coastal seas of China was correlated to the number of dust storm events, and the Asian dust events Granger cause bloom events in the Yellow Sea. In addition, we also found that the correlation between monthly occurrence of dust storms and monthly Chl a concentration varied from the China coastal seas, the East/Japan Sea, the subarctic North Pacific to the North Pacific subtropical gyre associated with different dust sources.

Atmospheric iron inputs and the sub-tropical Atlantic biogeochemical divide

Mark Moore
Ocean and Earth Sciences, University of Southampton, UK

The fixation of atmospheric dinitrogen by diazotrophs is a key component of the marine nitrogen cycle and is crucial for the overall maintenance of oceanic productivity. However the environmental controls on oceanic diazotrophs remain an object of debate, likely due to severe undersampling of the simultaneous activity of these organisms alongside potential forcing factors. It has frequently been suggested that the high iron requirement for the nitrogenize enzyme results in diazotrophs being particularly sensitive to dust associated atmospheric iron inputs. New data in support of this hypothesis, ranging from molecular characterization of key diazotrophic groups, to atmospheric aerosol and upper-ocean micro- and macro-nutrient distributions, are presented for the Atlantic Ocean. Furthermore a meta-analysis of new and published data collected during multiple cruises is compared to a highly idealized numerical model. It is shown that observed relationships are entirely characteristic of a system consisting of three principal nutrients, iron, phosphorous and nitrogen, and two broad interacting functional groups, diazotrophs and non-diazotrophic phytoplankton. It is illustrated that the higher iron requirement for diazotrophs can then result in atmospheric dust inputs acting as a switch to flip the system between two biogeochemical states. We conclude that atmospheric dust inputs have a profound influence on the inter-basin differences in nutrient cycling in the Atlantic, with potential global implications.

Atmospheric nutrient inputs to the western Pacific

Tim Jickells
School of Environmental Sciences, University of East Anglia, Norwich, UK

Atmospheric inputs of nutrients (N, P and Fe) are significant compared to fluvial and other external sources and may affect euphotic zone primary production. We present the results of aerosol sampling on commercial vessels operating in the western Pacific between New Zealand and Japan. This data is used to provide estimates of nutrient inputs to the western Pacific. We use inter-element relationships and trajectory analysis to investigate atmospheric nutrient sources along this transect. Our results show a strong influence of Asian emissions in the northern Pacific and much lower concentrations throughout the South Pacific region sampled reflecting both the strength and location of source regions in relation to air flow climatology. We compare the results to those from similar latitudinal surveys in the Atlantic Ocean and also estimate the potential impact of atmospheric deposition on ocean primary productivity in the western Pacific.

Plenary talks

Theme: SOLAS and the future ocean

Rising atmospheric CO_2 and ocean acidification

Scott Doney
Marine Chemistry & Geochemistry, Woods Hole Oceanographic Institution, Massachusetts, USA

Atmospheric carbon dioxide (CO_2) levels are rising because of human activities, primarily the burning of fossil fuels, and contemporary atmospheric levels are almost 40% higher than during the pre-industrial era. About a quarter of current human CO_2 emissions are removed from the atmosphere into the ocean, resulting in lower pH and altered inorganic carbonate chemistry in surface waters. These chemical changes, often termed ocean acidification, are documented by open-ocean time-series and global ship surveys. Numerical models indicate that ocean acidification will continue and likely accelerate over the next several decades in tandem with continued CO_2 emissions. Ocean acidification has the capacity to affect marine life in both direct and indirect ways. One of the best-studied direct effects involves reduced calcification rates by organisms that form calcium carbonate shells and skeletons, such as some plankton, mollusks, corals, and coralline algae. Other physiological effects under investigation include respiration, photosynthesis, acid-base balance, reproduction, settlement, excretion, and behavior. The aggregate of these individual organism responses has the potential to affect biological populations, communities and whole ecosystems reflected in altered species ranges and seasonal phenology, disrupted trophic relationships, and shifting habitats. Marine biogeochemistry may also be sensitive to changes in nitrification and nitrogen fixation rates, dissolved organic carbon production, elemental stoichiometry of plankton biomass and detritus, and the ratio organic to inorganic carbon in export from the upper ocean. Ocean acidification may also have synergistic effects with other human stressors including climate warming, nutrient eutrophication, expanding hypoxia and coastal habitat degradation.

Understanding how multiple anthropogenic stressors will alter ocean biogeochemistry

Cliff Law for Phil Boyd
National Institute for Water and Atmospheric Research (NIWA), Wellington, New Zealand

Climate-change modelling experiments have revealed that the environmental properties which characterize the world ocean will be fundamentally altered in the coming decades. The properties that will be affected include temperature, nutrient supply, light climate and pH. Their concurrent alteration will have a major influence on both marine biota and the structure of ecosystems. These changes, in turn, will influence ocean biogeochemistry and will probably result in significant feedbacks on the changing climate. Moreover, there is growing evidence that our understanding of the effects of these concurrently changing properties on ocean biogeochemistry will be further confounded by the interplay between these altered properties. For example, manipulation experiments in which marine biota were exposed to both warming and higher CO_2 resulted in synergistic (i.e. amplification or diminution) effects, depending on which species was manipulated. Such interactive effects will make it problematic to identify the cause of any changes in the fitness of the biota that make up marine ecosystems. Our increasing awareness of how global environmental change will alter the world ocean is helping us rise to the challenge of understanding the complex interactions within a cluster of changing ocean properties and their biogeochemical implications. In order to better identify, catalogue and quantify biogeochemical responses to a changing climate, we must take a holistic view of the effects of global environmental change. Only with such an all-inclusive approach will we be able to subsequently predict the sign and magnitude of these biogeochemical feedbacks.

Talks

Theme: Air-sea gas fluxes at eastern boundary upwelling and oxygen minimum zone (OMZ) systems

Sorting out possible scenarios about the future of oxygen minimum zone systems

Andreas Oschlies (keynote speaker)
GEOMAR | Helmholtz Centre for Ocean Research Kiel, Marine Biogeochemistry, Kiel, Germany

Biogeochemical ocean circulation models have been used to predict the potential evolution of the marine oxygen distribution under a range of CO_2 emission scenarios. Using such a model, it will be shown how different assumptions about the sensitivity of biogeochemical processes to changing environmental conditions such as mixing intensity, temperature, redox state, and carbonate chemistry can affect the simulated evolution of oxygen minimum zones and air-sea fluxes of CO_2 and N_2O. It turns out that different model configurations, which show a similar agreement with observed current biogeochemical tracer distributions, can simulate very different future states of oxygen distributions, CO_2 uptake and N_2O emissions. A number of metrics will be investigated with respect to their ability to assess the quality of different model configurations, to identify model deficiencies and to reduce uncertainties. It is shown that we cannot rule out scenarios that may seem surprising, such as a decrease in 21st century marine suboxia or a warmer future ocean containing more oxygen than the present one.

Dinitrogen fixation above Oxygen Minimum Zones

Sophie Bonnet
Mediterranean Institute of Oceanography, Institut de Recherche pour le Développement, CNRS, Aix-Marseille University, France

The N budget for the global ocean is poorly constrained, with some reports suggesting that sinks exceed sources. N_2 fixation (one of the major sources of N) has been commonly studied over the past few decades in large oligotrophic areas depleted in N, such as subtropical gyres. It is indeed believed that N_2 fixers are not competitive in N rich areas, or do not fix N_2, which is a costly process in terms of Fe and energy. However, recent geochemical studies based on N:P ratios indicate that N_2 fixation could be important above Oxygen Minimum Zones (OMZs), and spatially coupled to N-loss processes. Some recent studies conducted in the Eastern Tropical Pacific OMZ confirm that N_2 fixation rates, despite variable, are in the same order of magnitude than those commonly measured in oligotrophic gyres. Ongoing research is currently focused on determining environmental factors responsible for the observed variability. Recent field data will be discussed in light of physiological and molecular studies conducted under controlled conditions. These results have potentially strong consequences as these new sources of fixed N need to be taken into account in biogeochemical budgets and models, especially in the context of probable OMZ extension in the future ocean.

Plenary talks

Talks

Cycling of nitrous oxide, methane and dimethylsulphide at the Candolim time series station in the Arabian Sea

Damodar M Shenoy
National Institute of Oceanography (CSIR), Dona Paula, Goa, India

The present scenario of global change is a direct result of industrialization and our present way of living. Studying gases like nitrous oxide, methane and dimethylsulphide is of great importance as they play an important role in the radiation balance of the earth. While the oceans produce half of the world's oxygen they are also responsible for the production the above mentioned gases. While nitrous oxide and methane have a positive feedback to the global warming phenomenon, dimethylsulphide on the other hand has a negative feedback. Thus studying the cycling of these gases in the marine environment holds the key to future mitigation procedures. The Arabian Sea is one of the unique basins of the World oceans. It is bounded on the north by the Asian land mass and holds one of the thickest (~ 1 km) oxygen minimum zones (OMZ). The OMZ exists because of poor ventilation of waters coupled with high primary production, which is a result of upwelling along the western boundary during the southwest (SW) monsoon and convective upwelling in the northern central Arabian Sea during the northeast monsoon. In addition to the perennial OMZ, the Arabian Sea also experiences seasonal anoxia along the eastern boundary, where upwelling is weak. The difference in the residence times of the upwelled waters has a profound impact on the production of nitrous oxide, methane and dimethylsulphide. The establishment of a quasi-time-series station off the Candolim coast, Goa (nick-named as the Candolim times-series; CaTS) helped unravel the cycling of these gases. Towards the end of SW monsoon the region experiences complete anoxia with the production of hydrogen sulphide. During this event we have observed some of the highest concentrations of nitrous oxide (~0.8 µM), methane and dimethylsulphide (~0.4 µM) observed so far from an open ocean system. The present study discusses the evolution of anoxia and the production of nitrous oxide, methane and dimethylsulphide at the CaTS station.

Influence of the subtropical OMZ in the inorganic carbon along the Pacific Mexican Coast

José Martín Hernández-Ayón
Instituto de Investigaciones Oceanólogicas, Universidad Autónoma de Baja California, Ensenada, Baja California, Mexico

In the Mexican Coast, spatial variability can in just kilometers, for example south of 30°N are on the annual average, a CO_2 source to the atmosphere, whereas north of 40°N is a sink, and between 30° and 40°N is neutral. In the Mexican Pacific, seasonal CO_2 fluxes related with OMZ were identified along the coast using CO_2 measurement. But also, values of Ω aragonite <1, low oxygen and rich DIC where observed nearest the surface and close to subtropical areas. In the subtropical, these proprieties were observed in ~70m. Good relationship was observed between equatorial subsurface water and the above chemistry. This water mass is considered part of the OMZ. Results from several cruises from the Imecocal program (Investigaciones Mexicanas de la Corriente de California), some opportunity cruises and measurements from two buoys support the roll of subtropical waters from OMZ in the carbon chemistry from north Mexican coastal waters.

Plenary talks

Theme: Emerging themes

Budgets and distribution of ^{137}Cs and ^{134}Cs in the North Pacific Ocean: impacts of global fallout, Chernobyl and Fukushima NPP accidents

Michio Aoyama
Geochemical Research Department, Meteorological Research Institute, Japan

Distribution and inventory of ^{137}Cs which originated from atmospheric weapons' tests have been studied in the Pacific Ocean since late 1950s. At January 1970, ^{137}Cs inventory in the North Pacific Ocean was 290±30 PBq and it decreased to 86 PBq in 2003 because its radioactive decay and inter-basin transport from the North Pacific Ocean to Indian Ocean and the South Pacific Ocean. Since impact of Chernobyl accident at the Pacific region was small, increase of ^{137}Cs activity in the waters in the North Pacific Ocean was only doubled. Impact of Fukushima NPP accident to the North Pacific Ocean occurred through two pathways, namely direct release and atmospheric transport to wide ocean surface. Near the Fukushima site, ^{134}Cs activity in surface water increased up to 68 x 10^6 Bq m^{-3} in April 2011. ^{134}Cs was also detected east of data line north of 40 deg. N in the Pacific Ocean in April 2011 of which activity ranged from 2 Bq m^{-3} to 12 Bq m^{-3}. The activity ratio of ^{134}Cs vs. ^{137}Cs was 0.99±0.02 near the site. Total amount of direct release of ^{134}Cs was estimated to be 3.5±0.7 PBq and that by atmospheric transport was estimated to be 12-15 PBq together with equivalent amount of ^{137}Cs, respectively. Just before Fukushima accident, about 69 PBq of ^{137}Cs was in the North Pacific Ocean, therefore, newly added ^{137}Cs is estimated to be 23% - 27% of total inventory of ^{137}Cs in the North Pacific Ocean.

Which factors determine spring biological bloom in the China Sea?

Xiaohong Yao
Key Laboratory of Marine Environment and Ecology, Ocean University of China, Ministry of Education of China, Qingdao, People's Republic of China

In last decades, dozens of studies proposed that there was a causative link between dust events and spring biogenic bloom in China seas. However, a careful examination including the dust-derived elemental stoichiometry and environmental factors was still rare. In this study, we presented a long-term correlation analysis between dust-storm events and spring bloom in the China Sea, a cruise campaign in which dust events and spring bloom were observed sequentially in the Yellow Sea, and three incubation experiments in the China Sea. The long-term correlation analysis shows that Granger causality relation between the frequency of dust events and that of spring bloom was present only in some areas of the China Sea. In the cruise campaign, the atmospheric input instead of the oceanic input from bottom dominated the supplies of nutrients in the surface water in the central Yellow Sea during the dust event. When comparing estimations of the dust-derived nutrient supplies with plankton community needs, we found that the dust-derived N supply nearly satisfied the bloom phytoplankton need in the initial stage; while, the dust-derived Fe supply far exceeded the total need of bloom biota. Granger causality test results further supported the causality link with 3-5 days extra lags. Three incubation experiments in the China Sea were further conducted to explore individual impact of various factors. Overall, interactions of Asian dust and anthropogenic air pollutants from the city cluster of China apparently play an important role in determine the occurrence of spring bloom in the China Sea.

Iron fertilization by volcanic ash: Implications for ocean carbon uptake

Roberta Hamme
School of Earth and Ocean Sciences, University of Victoria, British Columbia, Canada

Volcanic ash was recognized as a potentially significant iron source to the ocean some two decades ago, along with speculation that volcanic eruptions could result in discernable ocean uptake of atmospheric CO_2. The eruption of Kasatochi Volcano, in the Aleutian Islands, Alaska, in August 2008 followed by a phytoplankton bloom throughout most of the subarctic northeast Pacific was the first directly-observed, wide-scale example of this mechanism. A storm system forming over the volcano at the time of the eruption distributed ash over an unusually large oceanic area. The subsequent bloom was documented by satellite, mooring, seaglider, and traditional ship-based observations. These measurements showed increased chlorophyll and productivity in the surface ocean over the area of likely ash deposition as well as evidence of higher diatom abundances typical of iron fertilization. Decreases in surface ocean pCO_2 and increases in pH, which could only have been caused by organic matter production, began within days of the eruption. Despite the large size of the bloom (approximately two million square kilometers) at an optimal time of year, there was only an estimated 0.01 Pg of extra carbon uptake from this event. This suggests that volcanic eruptions may not be an efficient carbon sequestration mechanism.

New developments in the field of marine organic matter composition and cycling

Lihini Aluwihare
Scripps Institution of Oceanography, Geosciences Research Division, La Jolla, California, USA

The chemical composition and biogeochemical cycling of the vast majority of marine organic matter (OM) in the water column remains poorly understood. However, recent analytical advances have revitalized this area of research. For example, advances in isolation techniques have increased the fraction of dissolved organic matter (DOM) available for study; chemical characterization has been advanced through application of sophisticated multidimensional nuclear magnetic resonance spectroscopic (NMR) techniques, chromatographic separation methods, and mass spectrometric (MS) techniques with high mass accuracy; radiocarbon measurements can now be made on small sample sizes, opening the door to wider-application of compound-specific radiocarbon analyses. Finally, new studies show that stable isotopes are capable of distinguishing the biological source of individual organic compounds in the upper ocean. This talk will highlight some of the progress catalyzed by these recent analytical advances. For example, several new insights have been provided into the composition of DOM: changes in carbohydrate composition may identify changes in phytoplankton community structure, and in oligotrophic environments, carbohydrate degradation affects composition in a predictable manner. Mass spectrometry and NMR studies have identified highly carboxylated, aged aliphatic compounds to be important constituents of DOM, related studies have identified thermogenic, polycyclic aromatic compounds accumulating in DOM, and the occurrence and distribution of some organic sulfur and organic nitrogen compounds in seawater have also been described. In addition, this presentation will discuss new insights into residence time and source of marine OM being provided by radiocarbon and stable isotope measurements.

Discussion sessions

The discussion sessions are intended to provide an informal opportunity for round table discussions of hot topics, with the aim of fostering collaborations and furthering research. Three sessions will take place in parallel each afternoon (see Programme) as well as a plenary discussion session on Tuesday 8 May.

Sessions will be 1h30min with a short (maximum 20 min) introduction. This introductory slot may include several short (1 slide) presentations, although these sessions are not intended as an arena for formal presentations. The remainder will be allocated to discussion.

A rapporteur will take minutes during each session and submit a report to SOLAS after the conference detailing the discussion and outcomes of the session for inclusion in the SOLAS Newsletter.

Monday 7 May 16:00 - 17:30

The three discussion sessions below will take place in parallel

Climate impact of seasalt-derived Cl atoms

convened by **Roland von Glasow[1] and Eric Saltzman[2]**

[1] School of Environmental Sciences, University of East Anglia, Norwich, UK
[2] School of Physical Sciences, University of California, Irvine, California, USA

Background and motivation

There is increasing observational evidence for the activation of seasalt-derived chlorine over the oceans. This chemistry leads to the production of Cl atoms which are highly reactive towards methane. Recent observations suggest that transport of anthropogenic emissions over the oceans can impact the rate of Cl cycling and the abundance of Cl atoms, but regional or global estimates of Cl cycling have not been made. The focus of this discussion is to start developing a coordinated field/laboratory/modelling strategy to answer the following questions:
1) Is tropospheric Cl chemistry a significant aspect of atmospheric reactivity, and to what extent is this a natural vs anthropogenic effect?
2) Do we have to include chlorine chemistry in future climate models to improve the calculation of the radiative forcing and if so, what level of process understanding is required?
This discussion session is organised by the SOLAS/IGAC task team Halogens in the Troposphere (HitT)

Intended outcome, action or product following the discussion session

The intended outcome is to start shaping a coordinated field/laboratory/modelling strategy to answer the above raised questions.

Improving our understanding of and capacity for model projections of sea ice-ocean biogeochemistry

convened by **Nadja Steiner[1] and Clara Deal[2]**

[1] Institute of Ocean Sciences (IOS/DFO), Fisheries and Oceans Canada, Sidney, British Columbia, Canada
[2] University of Alaska Fairbanks, International Arctic Research Center, Alaska, USA

Background and motivation

Several current research projects focus on transport processes and interactions in and near sea ice within a climate change context. Concurrently, demand mounts for model predictions of climate change impacts on Arctic ecosystems. For practical purposes small-scale sea ice processes must be simplified and parameterized in biogeochemical models, requiring understanding and quantification of simulation-critical processes. How important are observed small-scale processes to the accuracy of climate change projections?
A key challenge is bridging the significant scales, both physical (sea-ice internal transfers to large-scale exchange processes) and biological (cellular to biogeographical regions) across time (metabolic to decadal cycles). What are the technical and logistical difficulties involved in transferring understanding gained from fine-scale observations and process measurements to coarse-scale models, to provide a conclusive picture over multiple scales?
We hope to engage observationalists and modelers in a discussion of model-data scaling issues and approaches.

Intended outcome, action or product following the discussion session

We will provide recommendations for transferring our understanding of sea ice biogeochemical processes gained from fine-scale observations to coarse-scale models, including guidelines for successful modeler-observationalist collaborations to be summarized in a short paper: What needs to be measured, and why?

Discussions

Parameterising *k* with parameters other than wind speed?

convened by **Christoph Garbe**

Image Processing and Modeling, Interdisciplinary Center for Scientific Computing (IWR), University of Heidelberg, Germany

Background and motivation

The most widely used parameterizations to describe air-sea gas exchange depend solely on wind-speed. This is not only due to the availability and ease in measuring wind speed, but also because it is recognized that wind is the dominant forcing of a range of important processes at the air-water interface. Depending on the scales of interest, current parameterizations are converging, at least with regard to constraining global inventories. On smaller scales, both temporally and spatially, purely wind-speed dependent parameterizations can be significantly biased and commonly exhibit large scatter. Recent advances of small-scale regional and meso-scale models are often limited by the accuracy of the chosen parameterization. At the same time, novel sensors and measurement techniques can now resolve transport processes at much smaller scales then previously possible. This leads to significant advances in our understanding of transport processes and insights into novel parameterizations.

Intended outcome, action or product following the discussion session

In this discussions session, the focus will be on parameterising air-sea gas exchange through the inclusion of parameters other than purely wind-speed. We want to discuss possible other parameters, both in terms of measurements in the field and for regional and global satellite products. In this discussions session, we would like to foster the dialogue between experimentalists, modelers and researches from satellite remote sensing. The outcome of this discussion session should be to identify needs and the feasibility of other parameterizations, both now and in the near future.

Discussion sessions

Tuesday 8 May 14:30-15:30 and 16:00-17:30

Plenary discussion session (14:30 - 15:30)
Where we've been, where we are, where we're going, and why we matter: the SOLAS science plan and its relevance to society
***convened by* SOLAS Scientific Steering Committee**

For more than a decade, SOLAS has fostered cutting-edge research in air-sea interactions, facilitating communication, coordinating and directing research, and advocating for new programs. During this period, the significance of earth system science to society has become increasingly apparent. It is now time to assess our progress on the original science plan and consider our future course. In a world where earth system science is coming under increasing political and public scrutiny, what is and should be the contribution of SOLAS science to society? We will discuss these issues within the context of the SOLAS mid-term renewal and the increasing focus of the SOLAS parent organization, IGBP (the International Global Biosphere Program) on sustainability of earth systems, including the human dimension.

The three discussion sessions below will take place in parallel (16:00 - 17:30)

Ocean-derived aerosol: Properties and climate impacts
***convened by* David Kieber[1] and Lynn Russell[2]**

[1] State University of New York, College of Environmental Science and Forestry, Chemistry Department, Syracuse, New York, USA

[2] University of California-San Diego, Scripps Institute of Oceanography, La Jolla, California, USA

Background and motivation
Recent evidence suggests that newly formed primary ocean-derived aerosols include a large number of organic-rich particles. In addition, ocean-derived volatile compounds are an important source of secondary marine aerosol. Both primary and secondary particles scatter solar radiation and serve as cloud condensation nuclei thereby affecting the earth's climate. However, the composition and production rate (and the associated temporal and spatial variability) of these particles are highly uncertain, precluding an assessment of their impact on tropospheric chemistry, upper ocean biogeochemistry, and climate. This session will focus on a discussion of processes that may control the composition, production and evolution of marine aerosol and novel measurement techniques required to advance the understanding of these processes. Discussion points will include: 1) organic composition of ocean-derived aerosols, 2) role of upper-ocean biogeochemical processes on the composition and fluxes of volatile compounds and primary marine aerosols, 3) seasonal and spatial variability in composition and production, and 4) potential affects of ocean-derived aerosols on cloud properties.

Intended outcome, action or product following the discussion session
A written summary of the aerosol discussion session, including new insights, controversies, or proposed science plan(s) will be included in an upcoming issue of SOLAS Newsletter as well as posted on the main SOLAS website.

Gas transfer at high wind speeds: Recent observations and constraints
***convened by* Rik Wanninkhof[1] and William Asher[2]**

[1] National Oceanic and Atmospheric Administration (NOAA), Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami, Florida, USA

[2] Applied Physics Laboratory, University of Washington, Seattle, Washington, USA

Background and motivation
Significant advances have been made in quantifying air-sea fluxes of radiatively important gases, and in measuring the factors controlling their exchange, in part, by the SOLAS community because of their great interest and expertise. A notable exception to this is exchange at high winds, where flux measurements for different gases made using different methods and spatio-temporal scales provide contradictory results. This session will summarize recent field results obtained from noble gas anomalies in the intermediate and deep ocean, measurements made during cyclones, gas mass balances in surface oceans, and micrometeorological techniques.

Intended outcome, action or product following the discussion session
The outcome of the session will be an assessment of which results can be explained within a conventional theoretical framework and which require rethinking of traditional explanations of gas fluxes and their forcing mechanisms. Recommendations will be made by the group as to priority studies to resolve differences between seemingly contradictory datasets.

Detection and monitoring large-scale impacts of ocean acidification
***convened by* Christoph Heinze[1] and Yukihiro Nojiri[2]**

[1] University of Bergen, Geophysical Institute & Bjerknes Centre for Climate Research, Norway

[2] Center for Global Environment Research (CGER), National Institute for Environmental Studies (NIES), Tsukuba, Ibaraki, Japan

Background and motivation
Though we know much more details about potential consequences of ocean acidification for the marine environment today than five years ago, it is still difficult to identify related impacts on the large scale. Present international biogeochemical sampling programmes may not be ideally designed to provide the appropriate information for such an impact assessment. What may these large scale impacts be, at which time frame would they emerge, and which variables would we need to measure and simulate in order to confirm/reject postulated consequences of ocean acidification? Which variables have to be measured now systematically and through which kind of spatio-temporal data coverage in order to determine ocean acidification impacts by re-occupations of sampling locations in one, two, or three decades from now (legacy data sets)? What are the best early warning indicators for dangerous ocean acidification impacts (sustainability link)?

Intended outcome, action or product following the discussion session
A brief recommendation paper on suggestions for a feasible and efficient ocean acidification large-scale impact observing system based on the presently available knowledge, including specific needs for legacy data sets, best early warning indicators, and obstacles/gaps to overcome.

Discussion sessions

Wednesday 9 May 15:00 - 16:30

The three discussion sessions below will take place in parallel

Earth Observations for SOLAS Science

convened by **Christoph Garbe[1], Véronique Garçon[2] and David Woolf[3]**

[1] Image Processing and Modeling, Interdisciplinary Center for Scientific Computing (IWR), University of Heidelberg, Germany
[2] The Centre National de la Recherche Scientifique (CNRS) / Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), Toulouse, France
[3] Environmental Research Institute, Centre for Energy and the Environment, North Highland College UHI, University of the Highlands and Islands, Thurso, UK

Background and motivation

Significant advances have been made in SOLAS sciences, improving our understanding of atmosphere-ocean interactions. However, there still exists a gap for assessing regional systems and their role in the global climate system. Satellite remote sensing can be used to close this gap. Recent advances in Earth observation (EO) technology have made possible improved global observations of several key parameters, governing the ocean-atmosphere interactions. In the coming years, an increasing number of EO missions will provide an unprecedented capacity to observe the sea-surface and the atmosphere, opening a new era in EO for ocean-atmosphere interactions science.

Intended outcome, action or product following the discussion session

In this session, we want to discuss recent advances of EO for SOLAS sciences. We would like to foster discussions between experimentalists, modelers and scientists from EO. Which satellite products would be required for different branches of SOLAS and in which areas can EO help us to improve our understanding. We will discuss these topics and give some examples of the recent ESA-SOLAS Oceanflux initiative.

Potential shifts in DMS flux from the ocean due to a changing climate

convened by **Jacqueline Stefels[1] and Rafel Simó[2]**

[1] University of Groningen, Centre for Life Sciences, Ecophysiology of Plants, Groningen, The Netherlands
[2] Institut de Ciencies del Mar, ICM-CSIC, Barcelona, Spain

Background and motivation

The CLAW hypothesis (1987) postulated a potential feedback between phytoplankton and global temperature through the emission of dimethylsulfide (DMS) and its influence on the albedo of marine clouds. In a recent review of the hypothesis, Quinn and Bates (2011) questioned the impact of DMS on global climate on the grounds of the lack of evidence for: (1) DMS being a significant source of CCN; (2) DMS-derived CCN having significant impact on cloud albedo; and (3) oceanic DMS production responding significantly to changes in surface temperature and/or incident solar radiation over climate-relevant time scales.

Intended outcome, action or product following the discussion session

In this session we would like to discuss the 3rd topic:

1. What is the potential for changes in regional DMS emission regimes?
2. What is the likelihood of such changes upon global climate change?

Those with experience with time series or regional/global studies, process studies, or model-based studies are all welcome.

Impacts of dust and ash on ocean productivity

convened by **Roberta Hamme[1], Rémi Losno[2], I-I Lin[3] and Diego Gaiero[4]**

[1] University of Victoria, British Columbia, Canada
[2] University Paris Diderot / CNRS / LISA, Paris, France
[3] National Taiwan University, Taipei , Taiwan
[4] Universidad Nacional de Córdoba, Argentina

Background and motivation

Fertilization of the ocean by inputs of macro- and micronutrients from dust and ash can stimulate ocean productivity, affect the structure of the marine ecosystem, and play an important role in the global cycling of key elements such as iron, nitrogen and carbon. However, these processes remain poorly understood due to their often sporadic nature and to the difficulty of sampling remote regions sensitive to dust deposition, such as the Southern Ocean. This session will discuss: 1) emission, transport, and impact area of dust/ash fertilization, 2) the dependence of deposition, release of elements, and response of the ocean to the particle source (soils, volcanic ash, or anthropogenic emissions), to wet vs. dry deposition, and to the state of nutrient limitation of the ocean region, 3) advances in modelling fertilization processes including future climatic change, and 4) the potential for these events to represent significant sinks for atmospheric CO_2.

Intended outcome, action or product following the discussion session

The aim of this discussion session is to build consensus within the SOLAS community on the state of knowledge of ocean fertilization by dust and ash, on the largest uncertainties in our understanding of this process, and on what future work (proposals and research topics) is needed in this arena.

Discussions

Please put your poster on your allocated, numbered poster board in the poster tent during the lunch break on the day of your poster session. Pins and tape will be provided.
All posters will be on display for one of the three poster sessions on Monday, Tuesday and Wednesday. Presenting authors should stand next to their poster for the duration of their designated session to present their research and answer questions. To ensure that similar numbers of posters are presented in each session the posters are divided according to nine themes (see below).

Session 1 Monday 7 May
- Air-sea gas exchange
- The carbon cycle

Session 2 Tuesday 8 May
- Ocean derived aerosols
- Dimethylsulphide
- Halogens

Session 3 Wednesday 9 May
- Aeolian input
- Biogeochemistry
- Long-lived greenhouse gases
- Oxygen Minimum Zone systems

Poster competition
In order to support students and encourage excellence, the Canadian Meteorological and Oceanographic Society (CMOS) awards prizes to the top three student posters. All participants registered as students will automatically participate in the competition. A panel of judges will identify the best posters based on research quality and presentation. Prizes will be awarded at the banquet on Wednesday 9 May.

Schedule
Poster titles and numbers are listed below in alphabetical order by presenting author.

Poster session 1: Monday 7 May

AUTHOR	TITLE	POSTER NO.
Air-sea gas exchange		
Downy, C	ESA Earth Observation data for the SOLAS community	1
Gonçalves, I	Impact of sea-spray in the balance CO_2 flux air-sea	2
Huebert, B	Direct measurement of the sea/air carbon monoxide flux by eddy covariance	3
Jørgensen, E	In situ evaluation of air-sea CO_2 gas transfer velocity in an inner estuary - with a special focus on the importance of using reliable CO_2-fluxes	4
Kozlova, E	Atmospheric signatures of air-sea exchanges of long-lived trace gases and O_2 as observed at the Cape Verde Atmospheric Observatory (CVAO)	5
Kräuter, C	Partitioning of the transfer resistance between air and water	6
Landwehr, S	Direct comparison of eddy covariance techniques for CO_2 flux over the open ocean	7
Laß, K	Surface-sensitive SFG vibrational spectroscopy: A way of assessing seasonal signatures of the sea surface nanolayer?	8
Loose, B	Toward a map of the gas transfer rate in the polar ocean: turbulence unique to sea ice provides alternative drivers of gas flux	9
Losno, R	SOLAS-France	10
McGillis, W	Sea Ice Gas Exchange Studies [2007 – 2012]	11
Mesarchaki, E	Air-sea exchange of volatile organic compounds - experimental results from a wind-wave canal facility	12
Miller, W	Air-sea CO_2 exchange across a broad latitude range in the eastern Pacific by eddy covariance	13
Nightingale, P	Air-sea gas transfer measurements in an upwelling filament off Mauritania	14
Nightingale, P	The Atlantic meridional transect: a science platform for use in SOLAS research	15
Richter, K	On the Schmidt number dependency of air-sea gas exchange with varying surfactant coverage	16
Richter, K	On the extrapolation of gas transfer rates from heat exchange measurements with active thermography	17
Rutgersson, A	Importance of buoyancy for air-sea gas transfer	18
Schnieders, J	Near surface turbulence by means of passive thermography and image processing	19
Sørensen, L	Parameterization of atmosphere-surface exchange of CO_2 over sea ice	20
Tempest, K	Kinetic isotopic fractionation of argon and neon during air-water gas transfer	21
Woolf, D	Oceanflux greenhouse gases	22
The carbon cycle		
Brown, K	Observations of air-ice-ocean CO_2 cycling during spring melt in Resolute Passage, Nunavut (Arctic-ICE 2010)	23
de Almeida, J	On the inclusion of the ocean's diurnal warming effect for the global air-sea CO_2 net budget estimation	24
Fay, A	Variability and trends in global ocean carbon uptake from in-situ pCO_2 observations, 1981-2010	25
Flecha Saura, S	Air-sea CO_2 exchange in a tidally dominated estuary of the SW Iberian Peninsula	26
Friedrichs, G	Methodological issues of CRDS based underway monitoring of surface ocean $\delta^{13}C(CO_2)$	27
Guo, X	Carbonate chemistry in the western South China Sea under the influences of the Mekong River plume and a cyclonic eddy	28
Hahm, D	Strong biological uptake of carbon in a polynya of the Amundsen Sea, Antarctica	29
Heinze, C	Changes in carbon uptake and emissions by oceans in a changing climate - CARBOCHANGE	30
Kern, B	Interactions between ocean and atmosphere in a chemistry climate model	31

Poster session 1: Monday 7 May continued

AUTHOR	TITLE	POSTER NO.
Miller, S	Variability of CO and CO_2 apparent quantum yield (AQY) spectra in the coastal South Atlantic Bight and the nothern Gulf of Mexico.	32
Minhui, Z	Variations of pCO_2 and its influence factors in the north branch of the Changjiang River Estuary	33
Nakaoka, S	Reconstructing the monthly pCO_2^{sea} distribution in the North Pacific using Self Organizing Map	34
Nomura, D	Antarctic and Arctic flooded sea ice acts as a sink for atmospheric CO_2 during spring and summer	35
Oliva Méndez, N	Evaluation of the presence of under saturated water as Aragonite, in Baja California Coast, Mexico	36
Park, K	Carbon monoxide emissions from the Southern Ocean estimated by underway measurements	37
Richardson, J	Cycling of carbon monoxide in the Delaware Estuary	38
Sievers, J	CO_2 interaction between the air and sea-ice in Arctic coastal waters	39
Smith, S	Modeling the carbon cycle as affected by temperature sensitivities of autotrophic production vs. heterotrophic degradation in the ocean	40
Steiner, N	Carbon fluxes and acidification in the Arctic - do climate modelers need to care about gas fluxes in ice covered regions?	41
Turk, D	Summertime pCO_2 in the Cumberland Sound in the Eastern Arctic	42
Watson, A	Is the sink for atmospheric CO_2 in the North Atlantic changing or not?	43
Williamson, P	Overview of the UK ocean acidification research programme in relation to SOLAS	44
Yasunaka, S	Estimation of sea surface dissolved inorganic carbon (DIC) in the North Pacific using pCO_2 mapping	45
Yu, P	The pCO_2 and air-sea fluxes in the Changjiang River estuary and adjacent Hangzhou Bay in summer	46
Zhou, J	Gas migration in sea ice: from observations to modelling	47

Poster session 2: Tuesday 8 May

AUTHOR	TITLE	POSTER NO.
Ocean-derived aerosols		
Bates, T	Measurements of ocean derived aerosol off the coast of California	1
Button, S	Photochemical and biological turnover of low molecular weight carbonyl compounds in the Delaware Estuary	2
Clarke, A	Organic carbon and non-refractory aerosol over the remote Pacific: oceanic and combustion sources	3
Ewert, M	Transport of marine microbes and polysaccharides from first-year sea ice into snow and implications for marine-atmospheric exchange	4

Poster session 2: Tuesday 8 May continued

AUTHOR	TITLE	POSTER NO.
Fomba, K	Aerosol chemical and trace metal characterization at the Cape Verde atmospheric observatory	5
Galgani, L	The gel-like composition of the sea surface microlayer: evidence of proteinaceous exudates enrichment in an indoor experiment	6
Gaston, C	Single-particle insights into the influence of biological activity on sea spray aerosol mixing-state	7
Hamacher-Barth, E	Characterization of high Arctic aerosol particles using scanning and transmission electron microscopy	8
King, S	Investigating primary marine aerosol properties: CCN activity of sea salt and mixed inorganic-organic particles	9
Kleber, J	Quantitative time-resolved vibrational sum frequency generation spectroscopy as a new tool to study organic film reactivity at the air-water boundary	10
Lawson, S	Characterising VOCS in the marine boundary layer during the SOAP voyage, Chatham Rise, 44° S	11
Lawson, S	Opportunities aboard Australia's new research vessel, the RV Investigator	12
Leck, C	On the chemical dynamics of biogenic polysaccharides in the high Arctic surface microlayer	13
Lewis, E	Magic - A year-long investigation of marine clouds in the Pacific	14
Meskhidze, N	The role of sea spray aerosols in climate assessments	15
Orellana, M	Sequencing of marine microgels in the high Arctic	16
Russell, L	Comparing the organic functional group composition of seawater, bubbled particles, and marine aerosol	17
Salter, M	A reductionist approach to the influence of marine biology on sea spray formation	18
Selleck, P	Long term trends of secondary aerosol components at Cape Grim baseline station	19
Tanimoto, H	Novel application of PTR-MS to study ocean biogeochemistry of organic trace gases of atmospheric importance	20
Volkamer, R	Controls from a widespread surface ocean organic micro layer on atmospheric oxidative capacity	21
Woodhouse, M	The influence of DMS and sea salt emission on marine aerosol: a statistical approach	22
Zhu, Y	The growth and shrinkage of atmospheric nanoparticles with property of potentially impacting the climate in Qingdao, China	23
Zindler, C	Marine sources and sinks of acetone and acetaldehyde	24
Dimethylsulphide		
Archer, S	Contrasting responses to ocean acidification of DMS and its precursor DMSP in Arctic waters	25
Bell, T	Measurements of dimethylsulfide air/sea gas transfer by eddy correlation in the North Atlantic	26

Poster session 2: Tuesday 8 May continued

AUTHOR	TITLE	POSTER NO.
Deal, C	Modelling the influence of sea ice on marine sulphur biogeochemistry in the Arctic	27
Huebert, B	DMS may not be the principal source of NSS in the remote tropical Pacific	28
Kinsey, J	Dimethylsulfide photolysis in the Gulf of Mexico	29
Koga, S	Variation of atmospheric DMS and aerosol number concentrations over the southern Indian Ocean	30
Law, C	Surface Ocean Aerosol Production (SOAP) in the south-west Pacific	31
Levasseur, M	Volcanic ash as an iron source to the iron-limited northeast subarctic Pacific	32
Nomura, D	DMS emission from Antarctic fast sea ice to the atmosphere during ice melt season	33
Simó, R	Shedding light on DMS production	34
Simó, R	High resolution, Lagrangian vertical profiles of dimethylsulfide reveal short-term response to environmental forcing	35
Stefels, J	Spatial variability of DMS, DMSP and DMSO in sea ice across the Weddell Sea	36
Steiner, N	A diel cycle study of dimethylsulfide at Ocean Station Papa	37
Tyssebotn, I	Late summer concentrations and biological turnover rates of acrylate and dimethylsulfoxide in the Gulf of Mexico	38
van Leeuwe, M	Salinity effects on dimethyl sulphide (DMS) production in sea-ice algae	39
Walker, C	Air-sea emission and near surface concentration of dimethylsulphide in the South-West Pacific	40
Halogens		
Buxmann, J	"Chlorine explosion" an autocatalytic release from sea salt aerosols	41
Granfors, A	Sea ice as a source of halocarbons in polar oceans	42
Hepach, H	Halogenated VSLS emissions from the Mauritanian upwelling	43
Hepach, H	Halocarbon sources and diapycnal flux in the Atlantic Equatorial Upwelling region	44
Hughes, C	Climate-induced change in biogenic bromine emissions from the western Antarctic Peninsula	45
Jickells, T	Ocean surface water iodine distribution and speciation and its impact on air sea-exchange	46
Kuyper, B	Bromoform production by two axenic marine diatom species	47
Lampel, J	Overview of DOAS measurements of reactive halogen species in the marine boundary layer	48
Leedham, E	Halocarbon production in the tropical coastal zone	49
Mattsson, E	Factors influencing the flux and distribution of halocarbons in Antarctic waters	50
Orlikowska, A	Dynamics of halocarbons in surface water during a short term mesocosm experiment	51

Poster session 2: Tuesday 8 May continued

AUTHOR	TITLE	POSTER NO.
Platt, U	The vertical distribution of BrO and aerosols in the Arctic: measurements by active and passive DOAS	52
Schulz-Bull, D	δ ^{13}Csignatures of bromoform in the sea water	53
Shi, Q	Production in variability of methyl iodide (CH_3I) in the surface ocean	54
Stemmler, I	Global modeling of methyl iodide production in the open ocean	55
Thornton, J	Temperature dependent halogen activation from halide-doped ice surfaces	56
von Glasow, R	Model simulations of bromine explosions in a smog chamber	57
von Glasow, R	Megacities in the coastal zone	58
Wittke, F	Global air-sea flux climatology of $CHBr_3$, CH_2Br_2 and CH_3I based on in-situ measurements	59

Poster session 3: Wednesday 9 May

AUTHOR	TITLE	POSTER NO.
Aeolian Input		
Bressac, M	Impact of Saharan dust deposition on dissolved-colloidal-particulate nutrient distribution in seawater	1
Ceylan, N	In cloud alterations of desert dust matrix and its impact on surface ocean	2
Crusius, J	Glacial flour dust storms transport bioavailable Fe to the Gulf of Alaska	3
Gaiero, D	Iron supplied to the Southern Ocean through recent volcanic ash derived from the Patagonian Andes	4
Gassó, S	Transport of Alaskan dust into the Gulf of Alaska and comparison with similar high-latitude dust environments	5
Guieu, C	A plan for a SOLAS campaign across the Mediterranean Sea in 2015	6
Heimburger, A	Atmospheric deposition of trace elements over the Southern Indian Ocean	7
Hinz, D	Cross-calibration of long pathlength absorbance vs. chemiluminescence flow injection for analysis of trace Fe(II) concentrations in aqueous media	8
Ito, A	Effect of estimation of dust size distribution at emission on iron deposition	9
Johansen, A	Aerosol ferrous iron concentrations correlate with carboxylic acids in the remote equatorial Pacific Ocean	10
Journet, E	A new mineralogical database for atmospheric dust to estimate soluble iron fluxes to surface ocean	11
Kieber, D	Phosphorus inputs and cycling in the Sargasso Sea	12
Scarratt, M	Contribution of ice algae to the marine pool of dimethylsulfoniopropionate (DMSP) in the Arctic	13
Lin, I	Fertilisation potential of volcanic dust in the low nutrient low chlorophyll western North Pacific subtropical gyre – satellite evidence and laboratory study	14

Posters

Poster session 3: Wednesday 9 May continued

AUTHOR	TITLE	POSTER NO.
Losno, R	Dust emission from Patagonia	15
Meskhidze, N	Improved representation of dust-nutrient deposition to the surface ocean	16
Ohde, T	Influence of Saharan dust on photosynthetically active radiation	17
Qi, J	Atmospheric dry and wet deposition of nitrogen species in the coastal waters of the Yellow Sea	18
Rohekar, S	An inventory of marine aerosol and rain data for global oceans	19
Schoemann, V	Iron stable isotopes: a tool to unravel the biogeochemical cycle of Fe in Antarctic sea ice	20
Zhang, T	Sources and atmospheric processes determining Fe solubility in TSP over the Yellow Sea, China	21
Zhang, Y	Comparing uncertainties in the transport and deposition of atmospheric dust elements into marine ecosystem based on two element sources assessment methods	22
Zhang, Y	Atmospheric deposition influenced by sea surface coarse current and its implication on biogeochemistry in China seas	23
Biogeochemistry		
Cervantes-Díaz, G	Temporal variability of inorganic carbon and nutrients off the coast of Ensenada, Baja California	24
Dahl, E	Are diatoms a source of oceanic alkyl nitrates?	25
Kiene, R	Dissolved methane and oxygen concentrations in shelf waters of the northern Gulf of Mexico impacted by the deepwater horizon oil spill	26
Langlois, R	Environmental influences on a marine diazotrophic gamma-proteobacteria (gamma a) abundance and activity	27
Laurent, A	Simulating the effects of phosphorus limitation in the Mississippi/Atchafalaya river outflow region	28
Law, C	No response of nitrogen fixation to elevated CO_2 in manipulation experiments in the South Pacific	29
Moore, K	Iron biogeochemistry and the Eastern Pacific Oxygen Minimum Zones	30
Nishioka, J	Pivotal roles of sea ice on iron transport in the Sea of Okhotsk	31
Stanley, R	The effect of sea ice on gross primary production and net community production: a study in the Canada Basin	32
Steinhoff, T	Observing diel cycles of biogeochemical parameters with an autonomous Lagrangian surface drifter	33
Steinhoff, T	Biological productivity in the Mauritanian upwelling estimated with a triple gas approach	34
Triquet, S	Remote atmosphere sampling and storage for mercury and very low level trace metals	35
Wang, S	Impacts of sea ice on the iron cycle and marine ecosystems	36

Posters

Poster session 3: Wednesday 9 May continued

AUTHOR	TITLE	POSTER NO.
Zhang, G	Dissolved CH_4 in the East China Sea: distributions and biogeochemistry	37
Long lived greenhouse gases		
Bange, H	MEMENTO (MarinE MethanE and NiTrous Oxide database): towards a global database of oceanic Methane and Nitrous Oxide data	38
Bange, H	Underway N_2O and CO_2 measurements in the Equatorial Atlantic Ocean	39
Cornejo D'Ottone, M	Unaccounted N_2O sink in coastal and oceanic water off central Chile	40
Dai, M	Distribution and dynamics of nitrous oxide in the South China Sea and Pearl River Estuary	41
Kock, A	Effects of surfactants on nitrous oxide emissions from biologically productive regions	42
Rhee, T	Long-lived greenhouse gases (CO_2, CH_4, and N_2O) in the Pacific sector of the Southern Ocean and the Amundsen Sea between 2009 – 2012	43
Shao, A	Modeling the mixed layer saturations of CFC-11, CFC-12, and SF_6	44
Oxygen Minimum Zone systems		
Franco-Novela, A	CO_2 flux in the Oxygen Minimum Zone of the Mexican Tropical Pacific	45
Garbe, C	Climatically-active gases in the Eastern Boundary Upwelling and Oxygen Minimum Zone (OMZ) systems	46
Garçon, V	Physical and biogeochemical processes maintaining the Oxygen Minimum Zone of the Benguela Upwelling System using an eddy resolving model	47
Hernández-Ayón, J	Influence of the subtropical OMZ in the inorganic carbon along the Pacific Mexican coast	48
Montes, I	Maintaining of the Oxygen Minimum Zone in the Eastern Tropical Pacific based on a high-resolution coupled physical/biogeochemical model	49
Paulmier, A	AMOP: activities of research dedicated to the minimum of oxygen in the eastern Pacific	50

Transport to / from SeaTac airport

The nearest major airport is SeaTac International Aiport, 20km south of Seattle downtown and 143km west of the conference venue, Suncadia.
There are three ways to reach Suncadia from the airport.

SOLAS conference shuttle

SOLAS provides a free shuttle service between Seattle Sea-Tac Airport and Suncadia resort for conference attendees on Sunday 6 May. Return shuttle services between Suncadia and Seattle Sea-Tac Airport after the conference will be available on Thursday 10 and Friday 11 May.
Approximate travel time is 2 hours.

If you would like to use the shuttle service but have not booked a place please speak to IPO staff who will do their best to accommodate you.

from Airport to Suncadia	
	departing at
Sunday 6 May	14:00
	16:00
	18:00
	22:00

from Suncadia to airport	
	departing at
Thursday 10 May	13:00
	15:00
Friday 11 May	09:00

If you are arriving at Suncadia at dates or times when the shuttle service is not available please make use of the other local transport options below.

Airporter shuttle

A local airport transporter runs between Seattle Sea-Tac Airport and Cle Elum, the nearest town to Suncadia resort, 6 times per day. The timetable is available at http://www.airporter.com/schedules/schedules-rates-cwa
We recommend pre-booking although this service can be taken on site from the airport.
Prebooking for returns to the airport is essential as this is an advanced reservation only stop.

No taxis or public transport are available from Cle Elum to Suncadia. However, the staff at the resort can collect you from Cle Elum. Please call the resort on +1 (509) 649-6400 before leaving Seattle Sea Tac airport to inform Suncadia staff of your arrival time so they can meet you to complete your journey. Please identify yourself as a SOLAS OSC participant. Similarly Suncadia staff can transport you back to Cle Elum should you wish to take the airport shuttle on your return. Please let the front desk staff know in advance of your departure time.

Private car rental

Rental cars are available from several outlets at Seattle Sea-Tac Airport including Alamo, Hertz, Avis, etc. Parking is widely available on the Suncadia site and is free of charge (valet parking incurs an 8USD charge).

Driving Directions:

From Seattle: drive east on I-90 for 130 km and take exit 80 (Roslyn/Salmon La Sac). Turn left onto Bullfrog Road and follow the signs to Suncadia.

From Sea-Tac Airport: follow signs for I-405 North and drive until the I-90 East toward Spokane interchange. Drive east on I-90 for 130 km and take exit 80 (Roslyn/Salmon La Sac). Turn left onto Bullfrog Road and follow the signs to Suncadia.

From Portland: follow I-5 North and take exit 142A to merge onto WA-18 East (North Bend/ Auburn). Continue on Hwy 18 for 45 km and merge onto I-90 East (Spokane). Drive on I-90 East for 88 km and take exit 80 (Roslyn/Salmon La Sac). Turn left onto Bullfrog Road and follow the signs to Suncadia.

From Vancouver: follow Route 99 which becomes I-5 South and follow I-5 for 155 km. Merge onto I-405 South and proceed until I-90 East (Spokane) interchange. Drive east on I-90 for 130 km and take exit 80 (Roslyn/Salmon La Sac). Turn left onto Bullfrog Road and follow the signs to Suncadia.

Check in / check out

On arrival at Suncadia resort please make your way to The Lodge. This building is the venue for all conference sessions (except the welcome reception) and also houses most of the conference accomodation.

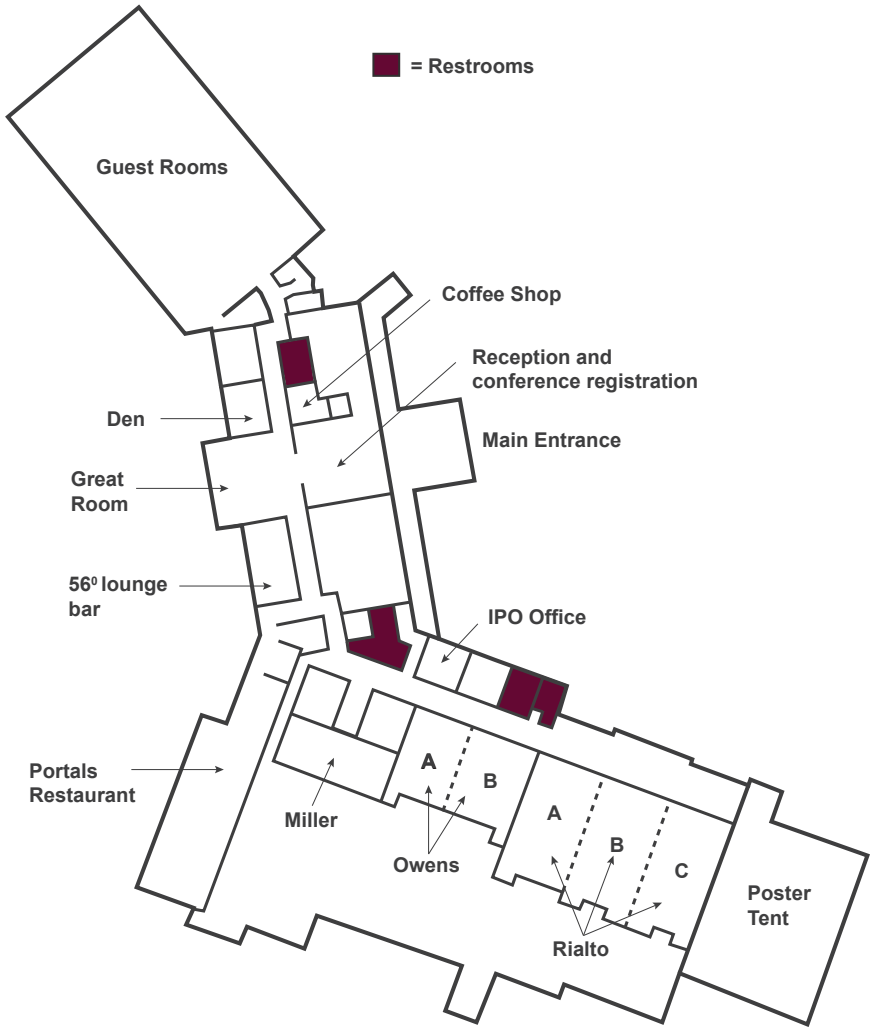
Guest accommodation will be available at 16:00 on arrival day and reserved until 11:00 on departure day. Any attendee wishing special consideration for late checkout should inquire at the front desk on the day of departure.

Registration

The conference registration desk will be open in the main reception from 14:00 until 22:00 on Sunday 6 May and on Monday 7 May from 07:00. If you arrive from Monday morning onwards and find the registration desk closed please ask for the Craven room (IPO office).
See map on page 44 for the reception desk location.

The Lodge @ Suncadia

The main conference programme takes place in The Lodge @ Suncadia. The map below shows the locations of plenary and discussion sessions as well as buffet meals and the majority of guest accomodation.



Further accomodation for conference attendees is located at the Inn. The swim and fitness centre are a short walk (500 metres) from the Lodge and the Swiftwater Cellars Winery (location for welcome reception) is a 1.6km walk away. Paths are well signposted to each venue.

Swim and fitness centre

Use of the swim and fitness centre is included for all conference attendees. Opening hours are from 06:00 till 19:00. Please sign in at the reception on each visit. Digital storage lockers and shower amenities are provided.
Guests can use both the indoor lap/leisure pool and outdoor heated pool, waterslides, whirlpool spa, sauna and steam room. The fitness centre includes extensive TechnogymTM cardiovascular and strength-training equipment.
Guests can also enjoy the outdoor hot tub at The Lodge and taking in the views of the Cascade Mountains

Further leisure facilities

There are many recreation activities which can be enjoyed in your free time during the conference or if you stay at Suncadia before or after the meeting including golf, hiking, biking, fishing, boating and horse riding.
There are more than 10 miles of paved paths and many more trails to enjoy on foot or by bike and the Glade Spring Spa offers a variety of treatments and access to outdoor mineral baths. Hours vary so please ask Suncadia staff for more information.

A variety of group activities will also be available during the conference in the extended lunch break. Please consult the activity boards for more information.

Local Info

Catering at Suncadia resort

Full board meals for all conference attendees are included within your registration fee (breakfast and lunch from Monday to Thursday and evening meal Monday to Wednesday).

Accompanying persons were given the option to choose a catering package at registration. Catering included in your package is indicated by the colour code on your conference badge as shown below. Please wear your conference badge to all meals.

Full conference attendee
* Welcome Reception
* Breakfast Buffet on conference days from Monday to Thursday
* Packed lunch on conference days from Monday to Thursday
* Dinner Buffet on Monday and Tuesday
* Conference Banquet on Wednesday

Accompanying person option 1: Conference Events
* Welcome Reception
* Conference Banquet on Wednesday

Accompanying person option 2: Morning & evening meals
* Welcome Reception
* Breakfast Buffet on conference days from Monday to Thursday
* Dinner Buffet on Monday and Tuesday
* Conference Banquet on Wednesday

Accompanying person option 3: **Full Board**
* Welcome Reception
* Breakfast Buffet on conference days from Monday to Thursday
* Packed lunch on conference days from Monday to Thursday
* Dinner Buffet on Monday and Tuesday
* Conference Banquet on Wednesday

Although many rooms at the resort have kitchen facilities please note that groceries are not available to purchase at the Suncadia resort. The nearest supermarket is in the town of Cle Elum 8km from Suncadia.

Drinking water

To save on plastic waste we will not be providing bottled water. However, filtered water will be available from dispensers outside the plenary rooms throughout the conference.
All tap water in Suncadia resort is also drinkable.

Breakfast

Breakfast is served from 06:30 untill 09:00 each morning in both the Great Hall and Portals Restaurant (see map page 44). Breakfast is buffet style with selections of fruits, cereals, breads, coffee, teas and juices along with daily cooked specials and continental standards.

Lunch

A boxed lunch is provided for all fully registered participants and accompanying persons on a full board package. Boxes will be available to collect each day from the Great Hall and Portals Restaurant after the morning plenary sessions finish at 12:30. Coffee and tea will also be available. Please feel free to enjoy your lunch in the Great Hall, Portals Restaurant or anywhere on the Suncadia site.
If you would prefer a hot lunch option there are several options onsite. The 56^0 lounge bar (see map page 44) is open Monday-Thursday 12:00 to 24:00 for sandwiches, sharables and light meals. The Swiftwater Winery is open on Wednesday - Sunday 12:00 to 16:00. Reservations can be made at reception. An in room dining service is also available from 06:00 to 22:00 - see the menus in your accomodations.
These dining options are not included in your package.

Evening meal

Buffet style evening meals will be provided on Monday 7 and Tuesday 8 May for all registered participants between 18:00 and 20:00 in rooms Rialto A and B (see map page 44). Vegetarian options are provided as standard. If you have any further dietary requirements or allergies please inform us as soon as possible and we will do our best to cater for you.
For those who have not booked a conference package or would prefer to diner à la carte the 56^0 lounge bar (see map page 44) will be serving food until 22:00. An in room dining service is also available untill 22:00. These options will incur a charge.
For further information on the conference banquet, Wednesday 9 May, see page 48.

Coffee breaks

Morning coffee will be served outside the plenary rooms (see map page 44) with coffees, teas, soft drinks and water available and a choice of daily snacks. Afternoon coffee will aslo be served outside the plenary rooms, please help yourself during breaks.

Snacks / room service

Coffees, cakes and snacks can be purchased from the coffee shop near to the main reception (see map page 44) from 06:30 to 17:00 daily. A small selection of beers, wines, crisps and chocolate are also available.
The 56^0 lounge bar (see map page 44) is open Monday-Saturday 12:00 to 24:00 (food served until 22:00) and Sunday 12:00 to 22:00 for sandwiches, sharables and light meals.
An in room dining service is available from 06:00 to 22:00 - see the menus in your accomodations.
Snacks and room service are not included in your conference package.

Beers / wines / spirits

Beers and wines will be provided at the welcome reception, Wednesday poster session and conference banquet. A cash bar selling a variety of beers, wines, spirits and soft drinks will be open during all poster sessions.
Drinks can also be purchased from the 56 degrees lounge bar or coffee shop (see map page 44) and via room service.

Welcome reception

All conference participants are invited to a welcome reception on the evening of Sunday 6 May 2012. The venue will be Swiftwater Cellars (www.swiftwatercellars.com), a winery within the Suncadia resort a short walk (approx 1 mile) from the main conference venue and accommodations. Shuttles will be available from main reception at the Lodge should you prefer transport and in case of bad weather. Join us from 19:00 for a light buffet and glass of locally produced wine followed by evening entertainment and drinks at the bar until 23:00.
Randi Coffman and Patrick Thayer, local Seattle talents, will be playing original songs and covers throughout the welcome reception.
The registration desk will open at 14:00 on Sunday 6 May at the main conference venue, the Lodge, and be staffed until 22:00. Please register before joining the welcome reception.

Poster sessions

All poster sessions take place in the poster tent (see map page 44).
Monday and Tuesday poster sessions take place after dinner. Coffee, tea, soft drinks, fruit punch and lemonade will be served in the poster tent from 20:00 to 22:00 alongside a cash bar for beers and wines.
The Wednesday poster session will be held before the conference banquet from 17:00 to 19:00. A choice of American themed snacks and local wines will be served alongside soft drinks and a cash bar. A short break follows before the evenings entertainment commences.

Conference banquet

The conference banquet takes place on Wednesday 9 May in rooms Rialto A, B and C (see map page 44) from 19:30 till 23:30 following the afternoon poster session. A delicious three course meal with local wines is included in your conference package.
The Voetberg Family Band from Chehalis, Washington will be playing throughout the evening. The band members, ranging from 9 to 22 years old, have won many awards including ten Washington State fiddle championships. After the meal and the Voetberg Family performance, the floor will be opened for dancing with student helper DJs in command.

Internet access

Wireless internet access is available in all guestrooms and meeting rooms. Wired Internet access is also available at all guestroom desk and network jacks. Please set your browser to detect internet settings automatically.
Computer workstations are available for delegates use including printing (airline boarding passes etc) in the Den (see map page 44).

Printing / photocopying

Guests have 24 hour access to two computers with internet connection in the Den (see map page 44). A printer is also networked to these computers for low volume printing such as airline boarding passes.
A photocopier service is available through the front desk. Copies are $0.05 each for black & white and $0.25 each for color.

Money exchange

A cash machine is available on site accepting the following cards: Visa, Master Card, AMEX, Discover, Diners Club, Star, Pulse, Cirrus, AFFN, Quest.
If in doubt please change currency into US dollars before arrival as there are no currency exchange facilities onsite.

Weather

Average monthly high for May 19°C / 66°F
Average monthly low for May 5°C / 41°F
Average monthly precipitation for May 24mm / 0.94inch

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