Poster Session

Monday, 05 December 2011

Time	Session Info
8:00 AM-12:20 PM, Halls A-C (Moscone South), **A11A. Aerosol, Cloud Properties, Atmospheric Rivers, and Precipitation in California: CalWater I Posters**	
	A11A-0041. Rainfall regime prevalence and water phase partition in atmospheric river systems observed offshore S.Y. Matrosov
	A11A-0042. Phase Characteristics in Orographic Convective Clouds J.M. Comstock; J.M. Tomlinson; J. Hubbe; C. Kluzek; B. Schmid; H. Jonsson; R. Woods
	A11A-0043. Three-dimensional structure and evolution of the Sierra Barrier Jet: A CalWater case study from 14-16 February 2011 D. Kingsmill; P.J. Neiman; S.E. Yuter; M.R. Hughes; B. Moore
	A11A-0044. The spatial distribution of precipitation frequency for atmospheric river storms in Northern California S.E. Yuter; D. Kingsmill; C. White; M. Wilbanks; N. Hardin; J. Cunningham
	A11A-0045. Inland Penetration of Atmospheric Rivers J.D. Means; D.R. Cayan
	A11A-0046. Aircraft Observations of Water Vapor Transport in Atmospheric Rivers: Synthesis from Seven Events Using Dropsonde Data from the NASA Global Hawk, NOAA G-IV, and NOAA WP-3D F.M. Ralph; G.A. Wick; P.J. Neiman; J.R. Spackman; Y. Song; T. Hock
	A11A-0047. Detection of Asian Dust in California Orographic Precipitation A.P. Ault; C.R. Williams; A.B. White; P.J. Neiman; J. Creamean; C.J. Gaston; F.M. Ralph; K.A. Prather
	A11A-0048. Recent Aircraft Observations of High Aerosol Loadings in the Northern Hemisphere Pacific J.R. Spackman; C.R. Williams; J.P. Schwarz; R. Gao; A.E. Perring; L.A. Watts; D.W. Fahey; D.C. Rogers; S.C. Wofsy
	A11A-0049. Distinguishing Features of Atmospheric River Storms Linked to Debris Flow Initiation on Mt. Hood, Oregon and Mt. Rainier, Washington J. Desrochers; A.W. Nolin

	A11A-0050. CCN and IN Effects on Cloud Properties and Precipitation – Case Studies from CalWater 2011 J. Fan; L. Leung; J.M. Comstock; J.M. Tomlinson
	A11A-0051. Diagnosis of Systematic Errors in Atmospheric River Forecasts Using Satellite Observations of Integrated Water Vapor G.A. Wick; P.J. Neiman; F.M. Ralph
	A11A-0052. Aerosol Impacts on Cloud Properties Observed during CalWater 2011 K. Suski; K.A. Prather; J. Hubbe; C. Kluzek; H. Jonsson
	A11A-0053. Rainfall Process Partitioning Using S-PROF Radar Observations Collected During the CalWater Field Campaign Winters A.B. White; P.J. Neiman; J. Creamean; M.R. Hughes; B. Moore; F.M. Ralph; K.A. Prather
	A11A-0054. In Situ Aerosol Properties Measured over the California Central Valley and the Sierra Nevada Mountain Range J.M. Tomlinson; J.M. Comstock; J. Hubbe; C. Kluzek; B. Schmid; H. Jonsson; R. Woods
	A11A-0055. Observing atmospheric rivers from the Global Hawk: HAMSR results from WISPAR11 S. Brown; B. Lambrigtsen
	A11A-0056. Sources and evolution of cloud-active aerosol in California's Sierra Nevada Mountains G.C. Roberts; C. Corrigan; S. Noblitt; J. Creamean; D.B. Collins; J.F. Cahill; K.A. Prather; J.L. Collett; C. Henry
	A11A-0057. A global atmospheric river climatology as simulated by the Community Atmosphere Model version 5 (CAM5), compared to results from reanalyses. J. Nusbaumer; D.C. Noone
	A11A-0058. Observations of Aerosol Conditions Associated with Precipitation Events in the Remote Sierra Nevada Foothills D.B. Collins; D. Kingsmill; G.C. Roberts; S. Noblitt; K.A. Prather
	A11A-0059. Exploring the relationship between a ground-based network and airborne CCN spectra observed at the cloud level. C. Corrigan; G.C. Roberts; J. Ritchie; J. Creamean; A.B. White
	A11A-0061. Direct Measurement of Cloud Condensation Nuclei Chemistry using a New Microfluidic Instrument During the CalWater 2011 Campaign S.D. Noblitt; G.C. Roberts; C. Corrigan; J. Creamean; D.B. Collins; J.F. Cahill; K.A. Prather; J.L. Collett; C. Henry

Final ID: A11A-0041

Rainfall regime prevalence and water phase partition in atmospheric river systems observed offshore

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Body: Wintertime storms having high impact on West Coast of North America are often a result of landfalling Atmospheric Rivers (ARs). Significant uncertainties in annual precipitation and extreme precipitation events in California result from uncertainties in the representation of ARs offshore. CalWater research objectives include improvements in model representations of ARs. Predictions of the rainfall regime prevalence (e.g., warm rain versus the bright band - BB rain) and water substance partitioning were identified as issues where models need improvements. In this study, CloudSat spaceborne radar measurements were used to analyze the AR vertical cross sections over ocean. Based on the one cold season CloudSat measurements, observational statistics of the rainfall regime prevalence were obtained. For BB rainfall, independent retrievals of total ice amount and mean rain rate were performed within the AR structures. It was shown that there is significant correlation between mean values of ice amount and resultant rainfall in AR BB precipitating events. Generally, the ice component becomes more abundant as a result of an AR landfall. Over ocean, the identifiable bright band was present in more than half of all observed AR cross sections. These observational findings can be used for model tuning purposes.

Final ID: A11A-0042

Phase Characteristics in Orographic Convective Clouds

J. M. Comstock; [1]; *J. M. Tomlinson;* [1]; *J. Hubbe;* [1]; *C. Kluzek;* [1]; *B. Schmid;* [1]; *H. Jonsson;* [2]; *R. Woods;* [2];
1. Pacific Northwest National Laboratory, Richland, WA, United States.
2. CIRPAS, Marina, CA, United States.

Body: Cloud liquid and ice phase partitioning is an important parameter in understanding cloud and precipitation processes. The relative amounts of liquid and ice in a cloud influence the microphysical, radiative, and dynamical feedbacks, impacting the cloud lifecycle and precipitation totals. Model simulations rely on observations of cloud microphysical properties to improve parameterizations of physical processes such as ice nucleation and riming efficiency. We utilize observations obtained using the Department of Energy Atmospheric Radiation Measurement Program's Gulfstream-1 aircraft to characterize cloud phase characteristics (i.e. mass content and number concentration) in convective clouds over the Sierra Nevada Mountains. We will present results using a unique set of cloud microphysical probes that measure binned size distribution and bulk mass content, combined with temperature, humidity, and vertical velocity information. Phase characteristics and the implications for cloud and precipitation processes will be presented for a series of flights in convective clouds under varying atmospheric conditions.

Final ID: A11A-0043

Three-dimensional structure and evolution of the Sierra Barrier Jet: A CalWater case study from 14-16 February 2011

D. Kingsmill; [1, 2]; *P. J. Neiman;* [2]; *S. E. Yuter;* [3]; *M. R. Hughes;* [1, 2]; *B. Moore;* [1, 2];

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3. Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC, United States.

Body: Atmospheric rivers (ARs) are narrow corridors of enhanced water vapor transport within extratropical cyclones. Although focused research during the last few years has yielded quantitative linkages between ARs and both the regional water supply and extreme precipitation events, questions remain regarding the modification and redistribution of precipitation in ARs by California's coastal mountains and Sierra Nevada. For example, rain rates are strongly correlated with the magnitude of the cross-barrier flow (and hence water vapor flux and uplift) at upper windward slope locations. However, at lowland locations they are poorly correlated due to the influence of low-level barrier airflows within the atmosphere. The most important of these barrier airflows is likely the Sierra Barrier Jet (SBJ), which is a dominant feature in Sierra Nevada storms. Winds reaching the mountain range often are partially stalled and, in part, diverted along the range rather than directed up and over. Knowledge of the impact of the resulting terrain-parallel barrier jets on orographic storms remains elusive. An incomplete understanding of the physics of and joint interactions between ARs and blocked flows limits our ability to identify the factors affecting the distribution and intensity of precipitation in California's Central Valley and along the Sierra's windward slopes. This study addresses these issues.

The most recent CalWater field campaign took place in northern California during the winter of 2011. A wide array of aerosol, cloud physics and meteorological measurements were collected. Documentation of SBJs and associated ARs was facilitated by a suite of scanning and profiling Doppler radars (wind retrievals and precipitation structure), balloon soundings (in situ thermodynamic and wind measurements) and GPS receivers (integrated water vapor retrievals). This presentation will provide an overview of the three-dimensional structure and evolution of the SBJ and AR observed during 14-16 February 2011 as part of the third Intensive Operating Period of CalWater 2011. The event produced the first significant rainfall for the region in almost 6 weeks and was particularly well observed from a meteorological, aerosol and cloud physics perspective.

Final ID: A11A-0044

The spatial distribution of precipitation frequency

for atmospheric river storms in Northern California

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3. ERSL/PSD, NOAA, Boulder, CO, United States.

Body: A key missing piece on the role of atmospheric rivers (ARs) in flooding events in California is knowledge of the detailed spatial distribution of precipitation over the slopes of the Coastal Range and Sierra Nevada. Existing rain gauges provide incomplete information on precipitation in this region, particularly over rugged mountainous terrain. We utilize operational radar data from National Weather Service WSR-88D radars at six locations in California and Nevada to determine the spatial distribution of precipitation frequency for selected AR events. Preliminary results suggest that the southerly moisture transport by the Sierra Barrier Jet becomes more southeasterly toward the north end of the Sacramento Valley and enhances precipitation in the lee of the Coastal Range.

Final ID: A11A-0045

Inland Penetration of Atmospheric Rivers

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Body: Precipitable water derived from GPS zenith delays is used to study the onshore penetration of enhanced moisture associated with landfalling atmospheric rivers. Precipitable water is the integral of the water vapor density from the surface to the top of the atmosphere, so its value is dependent on the elevation of the observation site, consequently inland locations, which are typically higher than coastal locations, will typically have lower values of precipitable water. This elevation dependence makes it more difficult to determine the inland penetration of the enhanced moisture associated with atmospheric rivers. Here we use two quantities that partially obviate this problem by normalizing the observed values: (1) the normalized precipitable water index (NPWI) defined by Zeng and Lu, and (2) a Z score that is modified for the lognormal distribution typical of precipitable water.   Using these quantities improves the ability to resolve the inland penetration of atmospheric river moisture, and shows that areas along the coast are still relatively enhanced with respect to inland areas.

Final ID: A11A-0046

Aircraft Observations of Water Vapor Transport in Atmospheric Rivers: Synthesis from Seven Events Using Dropsonde Data from the NASA Global Hawk, NOAA G-IV, and NOAA WP-3D

F. M. Ralph; [1]; *G. A. Wick;* [1]; *P. J. Neiman;* [1]; *J. R. Spackman;* [2]; *Y. Song;* [3]; *T. Hock;* [4];
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4. NCAR, Boulder, CO, United States.

Body: Atmospheric water vapor transport is a critical component of the global water cycle and in precipitation formation and prediction. Over roughly the last 15 years research efforts have identified atmospheric rivers (AR) as the primary mechanism for transporting water vapor in the mid latitudes, and possibly from the tropics into the midlatitudes. Numerous studies have used either satellite observations of vertically integrated water vapor (IWV) over the ocean or numerical models to examine AR-related water vapor transport. Some studies have been able to take advantage of vertical profiling information at the coast, and a handful of other studies have been able to carry out aircraft observations over the oceans.

This paper is intended to fill a major observational gap associated with quantifying the total amount of water vapor transport in several ARs using a unique set of dropsonde observations using research aircraft. The research addresses research objectives of CalWater associated with ARs. The analysis includes observations from 3 flights of the NASA Global Hawk unmanned aircraft in the NOAA-led Winter Storms and Pacific Atmospheric Rivers (WISPAR) field campaign that demonstrated for the first time a new dropsonde system built by NCAR for NOAA specifically for use on the Global Hawk. It will also document whether tropical water vapor was entrained into the southern extension of two strong ARs.

The study will also compare the observed characteristics of the AR water vapor transport (max IWV, max low-altitude winds, max local water vapor transport, and total water vapor transport across the depth and width of the AR) with standard meteorological analyses from the operational GFS numerical weather prediction model and from the ½ deg Climate Forecast System reanalysis (CFSR), the 32 km NARR, the NASA MERRA, and the coarser NCEP-NCAR Reanalysis.

Observations from the following field experiments and aircraft will be used:

-CalJet, NOAA P-3, 25-26 January 1998 (Ralph et al. 2004)

-Ghostnets/Atmospheric river study, NOAA P-3, 24-25 March 2005 (Ralph et al. 2011)

-WISPAR, NASA Global Hawk, 11-12 February 2011

-WISPAR, NASA Global Hawk, 3-4 March 2011

-WISPAR (with NOAA's Winter Storms Reconnaissance Program), NOAA G-IV, 3-4 March 2011

-WISPAR, NASA Global Hawk, 9-10 March 2011 (includes two AR crossings)

This analysis will quantify the water vapor transport within 7 AR events. It will use these data to assess uncertainties in the representation of ARs and their associated water vapor transport in standard meteorological analyses, i.e., GFS and several types of reanalysis of varying resolutions and methods.

Final ID: A11A-0047

Detection of Asian Dust in California Orographic Precipitation

A. P. Ault;[1, 2]; *C. R. Williams;*[3, 4]; *A. B. White;*[4]; *P. J. Neiman;*[4]; *J. Creamean;*[2]; *C. J. Gaston;*[5]; *F. M. Ralph;*[4]; *K. A. Prather;*[1, 5];

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5. Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, United States.

Body: Aerosols impact the microphysical properties of clouds by serving as cloud condensation nuclei (CCN) and ice nuclei (IN). By modifying cloud properties, aerosols have the potential to alter the location and intensity of precipitation, but determining the magnitude and reproducibility of aerosol-induced changes to precipitation remains a significant challenge to experimentalists and modelers. During the CalWater Early Start campaign (22 February – 11 March 2009), a uniquely comprehensive set of atmospheric chemistry, precipitation, and meteorological measurements were made during two extratropical cyclones. These two storms showed enhanced integrated water vapor concentrations and horizontal water vapor transports due to atmospheric river conditions and, together, produced 23% of the annual precipitation and 38% of the maximum snowpack at California's Central Sierra Snow Lab (CSSL). Precipitation measurements of insoluble residues showed very different chemistry occurring during the two storms with the first one showing mostly organic species from biomass burning, whereas the second storm showed a transition from biomass burning organics to the dominance of Asian dust. As shown herein, the dust was transported across the Pacific during the second storm and became incorporated into the colder high altitude precipitating orographic clouds over the Sierra Nevada. The second storm produced 1.4 times as much precipitation and increased the snowpack by 1.6 times at CSSL relative to the first storm. As described in previous measurement and modeling studies, dust can effectively serve as ice nuclei, leading to increased riming rates and enhanced precipitation efficiency, which ultimately can contribute to differences in precipitation. Future modeling studies will help deconvolute the meteorological, microphysical, and aerosol factors leading to these differences, and will use CalWater's meteorological and aerosol observations to constrain the model-based interpretations. The ultimate goal of such combined efforts is to use the results to improve aerosol-cloud impacts on precipitation in regional climate models.

Final ID: A11A-0048

Recent Aircraft Observations of High Aerosol Loadings in the Northern Hemisphere Pacific

J. R. Spackman; [1, 2]; *C. R. Williams;* [1, 3]; *J. P. Schwarz;* [4, 3]; *R. Gao;* [4]; *A. E. Perring;* [4, 3]; *L. A. Watts;* [4, 3]; *D. W. Fahey;* [4, 3]; *D. C. Rogers;* [5]; *S. C. Wofsy;* [6];

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6. Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA, United States.

Body: Recent aerosol and trace gas measurements from the HIAPER Pole-to-Pole Observations (HIPPO) study provide insight into the role of synoptic-scale variability on the intercontinental transport of pollutants between Asia and North America. These observations offer relevant upstream context for the CalWater study region. Four HIPPO campaigns with the NSF/NCAR G-V aircraft have been completed over all four seasons and include over 500 vertical profiles from 0.30 to 14 km altitude between 85°N and 67°S latitude in the remote Pacific and Arctic regions. The aerosol observations in the northern hemisphere Pacific exhibit large variability between and also within each season. Very polluted conditions were encountered over a deep portion of the troposphere in large-scale plumes in the springtime north Pacific midlatitudes and subtropics from anthropogenic and biomass-burning sources in Asia. Observations of black carbon (BC) mass loadings across the intertropical convergence zone show large interhemispheric gradients in boreal spring. The northern hemisphere BC mass loadings account for over 90% of the pole-to-pole burden of BC mass in the remote Pacific during this time of year. The goal of this analysis, directly relevant to CalWater science objectives, is to identify and characterize the role of aerosol-induced precipitation in major precipitation events (e.g., landfalling atmospheric rivers) along the west coast of the US. Here we first present the HIPPO observations and then lay the groundwork for an analysis that examines these data in the context of the large-scale meteorological flow and satellite-derived precipitation patterns to address this potentially important impact of anthropogenic and biomass-burning aerosol.

Final ID: A11A-0049

Distinguishing Features of Atmospheric River Storms Linked to Debris Flow Initiation on Mt. Hood, Oregon and Mt. Rainier, Washington

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Body: Strong eastern Pacific storms characterized by tropical-sourced moisture and heat are often referred to as Atmospheric Rivers (ARs) and are associated with the triggering of debris flows in the Cascade Mountain Range, USA primarily in the fall season. These storms typically feature freezing levels above 3000 m and heavy precipitation that can saturate slopes and rapidly melt shallow early season snowpack. In a study of periglacial debris flows on Mt. Hood, Oregon and Mt. Rainier, Washington, this combination of factors is proposed to initiate slope failure and subsequent debris flows. However, not all ARs trigger debris flows and other storms not associated with ARs may also lead to debris flows. The presence of these non-triggering storms has led to the question: what features distinguish the storms that trigger debris flows, and do these conditions differ between ARs and other storms? ACARS soundings are used to develop temporally detailed information about freezing levels and storm structure. Supplemental data from the SNOTEL network and NWS WSR-88D radar sites allow for better delineation of storm features and their impact on the ground. Antecedent snowpack, atmospheric temperature profiles, precipitation, and oragraphic enhancement are examined for storms associated with debris flows and those that failed to trigger events to determine what characteristics best differentiate the storms from one another. Specific features within the triggering storms, such as the presence of temperature inversions, are also examined for links to the elevation and geomorphic character of these periglacial debris flow initiation sites.

Final ID: A11A-0050

CCN and IN Effects on Cloud Properties and Precipitation – Case Studies from CalWater 2011

J. Fan; [1]; *L. Leung;* [1]; *J. M. Comstock;* [1]; *J. M. Tomlinson;* [1];
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Body: Aerosols in the atmosphere can serve as cloud condensation nuclei (CCN) and ice nuclei (IN) to modify cloud microphysical processes, which could potentially change the location, intensity, and type of precipitation. Dust aerosols are often observed over California in the Sierra Nevada Mountains in winter/spring, associated with long-range transport from Asia. Although anthropogenic pollution has been postulated to contribute to reduction of precipitation in the Sierra Nevada Mountains, the effects of dust aerosols on the winter clouds and precipitation has not been examined in detail particularly with model simulations. We incorporate recent progress in ice nucleation parameterizations to link dust with ice crystal formation in a spectral-bin cloud microphysical model coupled with WRF, to exclusively look into how dust can possibly affect cloud properties and precipitation type and intensity. Simulations are carried out for two cases under different environmental conditions with atmospheric river (AR) and Sierra barrier jet (SBJ) from the CalWater 2011 field campaign. It is shown that increasing IN concentrations or adding a dust layer at 4-6 km as IN enhances surface rain and snow due to enhanced production of ice and snow in clouds. However, increasing CCN suppresses surface rain and snow, and significantly redistributes surface precipitation upwind and downwind of the mountains, with important implication to improving our understanding of the impacts of aerosols on orographic precipitation and water supply in the region.

Final ID: A11A-0051

Diagnosis of Systematic Errors in Atmospheric River Forecasts Using Satellite Observations of Integrated Water Vapor

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Body: Narrow regions of strong water vapor transport in the atmosphere, termed atmospheric rivers, have been observed to be present and an important contributor to recent major winter flooding events along the west coast of the United States. CalWater research objectives include documenting the influence of atmospheric river (AR) events and assessing the uncertainty of their representation in numerical weather prediction forecast and reanalysis models. Understanding how well AR events are reproduced in model forecast fields is particularly important as we look forward to how their frequency and intensity might evolve in a changing climate. To support these goals, previous work defined objective characteristics for the identification of AR events in satellite-based integrated water vapor (IWV) retrievals. These techniques have been extended in the development of an automated tool to identify and characterize AR events in both satellite-derived and model fields of IWV.

To evaluate how accurately present models reproduce the occurrence and representation of AR events, forecasts and analyses of IWV from multiple models are compared with corresponding satellite-based retrievals over several cool seasons. The automated AR detection procedure is applied to compare the representation of such characteristics as the frequency, size, position, and intensity of AR events in both the analyses and forecasts. Forecast fields are taken from several of the operational models included in the THORPEX Interactive Grand Global Ensemble (TIGGE). Results are presented as a function of forecast lead time in terms of quantities including probability of detection and false alarm rate. Overall the frequency and timing of events is generally well forecast but the size and position are subject to larger errors, particularly at longer forecast lead times.

Final ID: A11A-0052

Aerosol Impacts on Cloud Properties Observed during CalWater 2011

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3. ARM Aerial Facility, Pacific Northwest National Laboratory, Richland, WA, United States.
4. Center for Interdisciplinary Remotely Piloted Aircraft Studies, Monterey, CA, United States.

Body: In February and March of 2011, an aircraft aerosol time-of-flight mass spectrometer (A-ATOFMS) was deployed on the DOE G-1 during CalWater, a multiyear field campaign aimed at understanding the effects of aerosols and atmospheric rivers on precipitation in California. Flights were conducted out of Sacramento and traversed the western coast of California to the eastern edge of the Sierra Nevada Mountain Range. Initial results show that when heavily processed Asian dust was present, clouds contained more ice than when dust wasn’t present, showing that cloud processed Asian dust acts as an efficient ice nucleus. In one particular cloud, salty, processed dust was at the core of most cloud droplets, while aged soot remained unactivated in the interstitial aerosol. These results show that atmospheric aging can have varying effects on CCN and IN abilities. Further analysis of chemical mixing state and atmospheric aging effects on cloud properties are presented.

Final ID: A11A-0053

Rainfall Process Partitioning Using S-PROF Radar Observations Collected During the CalWater Field Campaign Winters

A. B. White;[1]; *P. J. Neiman;*[1]; *J. Creamean;*[3]; *M. R. Hughes;*[2, 1]; *B. Moore;*[2, 1]; *F. M. Ralph;*[1]; *K. A. Prather;*[3]
;
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Body: Vertically pointing S-band radar (S-PROF) observations collected during the CalWater field campaign winter wet seasons are analyzed to partition the observed rainfall into three primary categories: brightband (BB) rain, non-brightband (NBB) rain, and convective rain. NBB rain is primarily a shallow, warm rain process driven by collision and coalescence. Because of its shallow nature, NBB rain is often undetected by the operational NEXRAD radar network. Previous rainfall process partitioning analysis conducted for a coastal mountain site in California has shown that NBB rain contributes about one-third, on average, of the total wet season precipitation observed there. Shallow moist flow with near neutral stability, which is often present in the coastal environment during the warm sectors of landfalling storms, is a key ingredient in the formation of NBB rain. However, NBB rain also has been observed in other storm regimes (e.g., post-cold frontal). NBB rain has been shown to produce rain rates known by forecasters to be capable of producing floods. During the CalWater field campaign winters, S-PROF radars were located in the Sierra Nevada at Sugar Pine Dam (SPD) for three consecutive winters (2009-2011) and at Mariposa (MPI) for the latter two winters (2010-2011). During the southwesterly flow present in the warm sectors of many California landfalling storms, the SPD site was directly downwind of the gap in coastal terrain associated with the San Francisco Bay Delta. This orientation would allow relatively unmodified maritime flow to arrive at SPD. The MPI site was located further south such that airflow arriving at this site during winter storms likely was processed by the coastal terrain south of San Francisco Bay. In this presentation we will examine whether the relative locations of SPD and MPI relative to the coastal terrain impacted the amount of NBB rain that was observed at each site during the CalWater wet seasons. We will use synoptic and mesoscale meteorological analyses to determine if flow through the coastal terrain gap may have contributed to increasing the fraction of NBB rain observed at SPD as compared to MPI. Finally, we will analyze the ambient and precipitation aerosol chemistry measurements collected during NBB rain periods at the SPD site to determine whether sea salt residues or other markers are present that would further support the hypothesis that a maritime-type environment contributed to the formation of NBB rain at SPD.

The percentage of seasonal rainfall attributed to NBB rain		
For winter season ending in	SPD	MPI
2009	38.8	.
2010	32.2[1]	14.1
2011	31.2[1]	16.0
Avg.	34.1	15.1

[1] For periods when both SPD and MPI S-PROFs were operating

Final ID: A11A-0054

In Situ Aerosol Properties Measured over the California Central Valley and the Sierra Nevada Mountain Range

J. M. Tomlinson; [1]; *J. M. Comstock;* [1]; *J. Hubbe;* [1]; *C. Kluzek;* [1]; *B. Schmid;* [1]; *H. Jonsson;* [2]; *R. Woods;* [2];
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2. Center for Interdisplinary Remotely Piloted Aircraft Studies, Marina, CA, United States.

Body: Anthropogenic aerosols are hypothesized to influence the formation of clouds and precipitation amounts within the Sierra Nevada Mountains. This could have a profound effect on the California water supply. To study this phenomena, an Ultra High Sensitivity Aerosol Spectrometer (UHSAS), Passive Cavity Aerosol Spectrometer (PCASP), and Cloud Aerosol Spectrometer (CAS) were operated aboard the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Aerial Facility (AAF) Gulfstream-1 aircraft from February 2 to March 6, 2011 during the CalWater field campaign. The combined aerosol size distribution from the three instruments characterizes the size-resolved concentration of the submicron and supermicron aerosol over the California Central Valley and Sierra Nevada Mountain Range. The measured aerosol size distributions from CalWater are compared with the size distributions measured during the DOE Carbonaceous Aerosol and Radiative Effects Study (CARES) in June 2010 to determine the changes in the aerosol size distributions during different seasons, atmospheric river events, and long-range transport events from Asia. These changes are used to estimate the resulting aerosol effect on cloud condensation nuclei concentrations and the potential impact on cloud formation and precipitation.

Final ID: A11A-0055

Observing atmospheric rivers from the Global Hawk: HAMSR results from WISPAR11

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Body: One of the Global Hawk unmanned aerial vehicles recently acquired by NASA was flown in a NOAA-sponsored field campaign to study atmospheric rivers and winter storms approaching the US west coast from the Pacific. The focus of the field campaign, the Winter Storms and Pacific Atmospheric Rivers (WISPAR), was to test out a new dropsonde system and the Global Hawk long-duration observing platform and their ability to provide observations with better coverage over a longer duration. NASA contributed the High Altitude MMIC Sounding Radiometer (HAMSR) microwave sounder developed at the Jet Propulsion Laboratory.

We will present an overview of the instrument and the campaign as well as observations of the vertical structure across two atmospheric river events deduced from HAMSR retrieved profiles of atmospheric temperature and water vapor. We also present a quantitative comparison to the co-incident dropsonde profiles.

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Sources and evolution of cloud-active aerosol in California's Sierra Nevada Mountains

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Body: To assess the sources of cloud-active aerosol and their influence on the hydrological cycle in California, the CalWater Experiment took place in winter 2011 in the foothills of the Sierra Nevada Mountains. During this experiment, we coupled the capabilities of demonstrated miniaturized instrumentation – cloud condensation nuclei (CCN), water condensation nuclei (WCN) and microchip capillary electrophoresis (MCE) – to provide direct chemical measurements of cloud active aerosols. Ion concentrations of CCN droplets attribute the anthropogenic, marine and secondary organic contributions to cloud-active aerosols. Detailed spectra from an Aerosol-Time-of-Flight Mass Spectrometer provide additional information on the sources of aerosol.

Storm fronts and changes in atmospheric boundary layer brought aerosol and anions associated with Central Valley pollution to the field site with CCN concentrations reaching several thousand cm^{-3}. Hygroscopicity parameters indicate aging of the organic fraction during aerosol transport from the Central Valley to the mountains. Otherwise, CCN concentrations were low when high pressure systems prevented boundary layer development and intrusion of the Central Valley pollution to the site.

MCE results show that nitrates and sulfates comprise most of the fraction of the aerosol anion mass (PM1). During the passage of storm fronts, which transported pollution from the Central Valley upslope, nitrate concentrations peaked at several μg m^{-3}. Low supersaturation CCN concentrations coincide with increases in aerosol nitrate, which suggests that nitrate has a role in cloud formation of giant CCN and, furthermore, in precipitation processes in the Sierra Nevada. CCN spectra show large variations depending on the aerosol sources and sometimes exhibit bi-modal distributions with minima at 0.3\% Sc -- similar to the so-called 'Hoppel minima' associated to number size distributions. During these bi-modal events, sulfate also increases supporting the addition of these anions during cloud processing. Chloride was also an important component following precipitation events indicating contributions of marine sources.

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A global atmospheric river climatology as simulated by the Community Atmosphere Model version 5 (CAM5), compared to results from reanalyses.

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Body: Atmospheric Rivers (ARs) are long, thin horizontal filaments of elevated moisture transport that can sometimes extend from the tropics up through the subtropics and into the midlatitudes. Understanding the dynamics and hydrology of ARs helps evaluate their role in the global climate system, especially given their presence in the relatively dry subtropics. ARs have also been known to cause extreme precipitation events, particularly for the west coast of the United States, so getting a better grasp on their variability on different time-scales could help forecasters more effectively predict the likelihood of one of these extreme events in the future. One of the major questions regarding ARs is how they might change as the climate warms, with particular concerns on future hydroclimatic changes along with potential influences on the radiative budget of the subtropics. Before changes in ARs in association with climate change can be evaluated in climate model projections, verifying that the models can accurately capture the relevant features of ARs and the frequency with which they occur in the present climate need to be established. This study examines the skill with which the Community Atmosphere Model version 5 (CAM5) can generate an accurate global AR climatology, and how this climatology compares to climatologies from the NCEP-NCAR and MERRA reanalyses. The model itself was chosen partially due to the presence of basic aerosol indirect effects in the model parameterizations. This study also examines how the simulation of ARs depends on the model resolution, dynamical core, and detection algorithm used to define the atmospheric rivers. It is found that the climatology of moist filaments simulated by CAM5 is similar to those of the reanalyses. This result is also fairly robust against changes in the dynamical core and model resolution, although the detection method chosen does appear to change the details of the final result. There also appears to be regional biases in the CAM5 simulation, which could indicate some potential issues if the model is used to study atmospheric rivers in a particular location. Still, results show that CAM5 is capable of simulating ARs, and suggests simulations of changes in atmospheric rivers with a changing global climate will be robust.

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Observations of Aerosol Conditions Associated with Precipitation Events in the Remote Sierra Nevada Foothills

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Body: Recent investigations of atmospheric aerosols have suggested their importance in affecting clouds and precipitation patterns, especially in regions where anthropogenic contributions to aerosol loadings are large. Aerosols entrained into precipitating clouds have been shown to either enhance or suppress precipitation based on the characteristics of the cloud condensation nuclei (CCN) or ice nuclei (IN) introduced. Due to the inherent chemical dependence of CCN activity, the chemical composition of aerosols introduced into precipitating clouds will determine their effect on precipitation. This presentation will utilize ground-based chemical and physical measurements of aerosols and precipitation from multiple winter seasons gathered at Sugar Pine Dam (Foresthill, CA) as part of the CalWater experiment. The coupled behavior of landfalling frontal systems, regional terrain-parallel flow along the windward slopes of the Sierra Nevada (i.e., the Sierra Barrier Jet), and observed aerosol conditions in the Sierra Nevada foothills will be demonstrated and related issues explored. Temporally correlated changes in aerosol chemical composition with approaching winter storms may provide key insights into the evolution of the Sierra Barrier Jet, a dynamic feature that can have a major influence on orographically-forced precipitation in this region, and could provide clues to the coupling of Central Valley pollution with winter-time orographic precipitation episodes (or lack thereof). Gaining an overall understanding of the frequency and magnitude of the entrainment of Central Valley pollutants on winter storm systems will ultimately provide an estimate of how much aerosols affect precipitation in California.

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Exploring the relationship between a ground-based network and airborne CCN spectra observed at the cloud level.

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Body: Cloud condensation nuclei (CCN) are aerosol particles that participate in the formation of clouds, and consequently, play a significant role in the influence of anthropogenic aerosols on atmospheric processes and climate change. Ultimately, the CCN of the most interest occupy the part of the atmosphere where cloud processes are occurring. A question arises as to whether in-cloud CCN are properly represented by the measurements of CCN at the ground level. While different locations may result in different answers depending upon local meteorology, the data set collected during CalWater 2011 may allow us to answer to what degree the ground-based observations of CCN are sufficient for evaluating cloud micro-physics over California's Central Valley and the lower slopes of the Sierra Nevada Mountains.

During CalWater 2011, ground observations were performed at three different altitudes to assess the evolution of cloud-active aerosols as they were transported from sources in California's Central Valley to the lower slopes of the Sierra Nevada Mountains. CCN spectra were collected over a supersaturation range of 0.08 to 0.80%. Results from these data sets show a diurnal cycle with aerosol concentrations increasing during the afternoon and retreating during the night. In addition, a CCN instrument was placed aboard aircraft for several flights and was able to collect vertical profiles that encompassed the altitudes of the ground sites. The flight data shows a large drop in CCN concentration above the boundary layer and suggests the highest altitude ground site at China Wall (1540 masl)was sometimes above the Central Valley boundary layer. By using estimates of boundary layer heights over the mid-altitude site at Sugar Pine Dam (1060 masl), the events when the China Wall site is near or above the boundary layer are identified. During these events, the CCN measurements at China Wall best represent in-cloud CCN behavior. The results of this analysis may be applied towards a better understanding of the ability of ground-based measurements of CCN to reflect what is happening at cloud level and if selective placement of these ground sampling sites might better capture cloud relevant data.

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Direct Measurement of Cloud Condensation Nuclei Chemistry using a New Microfluidic Instrument During the CalWater 2011 Campaign

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Body: The CalWater 2011 campaign took place in the California Sierra Nevada with the objective of determining the effects atmospheric rivers and aerosols have on California precipitation. To meet this goal, the role of chemistry on atmospheric aerosols' ability to act as cloud condensation nuclei (CCN) needed to be evaluated because not all aerosols are CCN active. To date, direct measurement of ambient CCN chemistry has been difficult or unobtainable because of the difficulty in obtaining a well-defined CCN population, small aerosol masses, and low measurement flow rates. To address this need, a miniature CCN collector was employed that directly deposits CCN-active aerosol into an aqueous sample solution in a microfluidic device. Microchip electrophoresis (MCE) then performs chemical analysis on the soluble CCN components, and concentrations of water-soluble inorganic anions were obtained. Additional instruments were run alongside the CCN-MCE system to obtain a more complete characterization of the aerosol, including MCE coupled to a collector for all water condensation nuclei (WCN), two aerosol time-of-flight mass spectrometers (ATOFMS), optical CCN counters, condensation particle counters, and aerosol sizing instrumentation.

The work discussed here will describe the operation of the CCN-MCE instrument and show the preliminary results obtained for CCN chemistry measurements at the Sugar Pine Reservoir during CalWater 2011. The prototype CCN-MCE analyzer permits online monitoring at a single, constant supersaturation. The outlet stream of the CCN system inertially impacts wetted CCN particles into a buffer-filled sample reservoir for immediate electrophoretic analysis, requiring <1 min per run. The integrated CCN-MCE system collects aerosols at ~0.05 lpm and deposits them into ~20 μL of solution, providing detection limits of ~0.1 μg per cubic meter with 10 min of sampling. Because of the low (mostly rural) aerosol concentrations monitored at the Sugar Pine Reservoir, a poorer time resolution of ~1 hr was used to improve detection limits and precision. Results showed that large concentrations of nitrate aerosol were transported into the Sierra from the California Central Valley in front of approaching storm fronts. This nitrate corresponded to increases in CCN counts at low supersaturation values, and measurements with the CCN-MCE (~0.13% supersaturation) showed that nitrate particles may act as giant CCN. Sulfate was also observed in the CCN chemistry but showed concentrations that were sometimes lower than those observed in the total aerosol analysis, indicating that ambient sulfate's CCN activity depended on particle size and/or mixing state. Comparisons between the CCN-MCE, WCN-MCE, ATOFMS, and size distribution data will be made to help elucidate which factors are important in determining precipitation in the California Sierra Nevada.