A U.S. – Japan Workshop on the Tropical Tropopause Layer: State of Current Science and Future Observational Needs

October 15 – 19, 2012

East-West Center
Honolulu, Hawaii

Workshop Program

Valparaiso
University

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Workshop general information available online at:
http://physics.valpo.edu/TTLworkshop/

Workshop proceedings archive available online at:
http://scholar.valpo.edu/ttlworkshop/

A U.S. – Japan Workshop on the Tropical Tropopause Layer: State of Current Science and Future Observational Needs

October 15 – 19, 2012
East-West Center, Honolulu, Hawaii

ORGANIZING COMMITTEE: Andrew Gettelman (NCAR, andrew@ucar.edu), Kevin Hamilton (University of Hawaii, kph@hawaii.edu), Fumio Hasebe (Hokkaido University, f-hasebe@ees.hokudai.ac.jp), Gary A. Morris (Valparaiso University, Gary.Morris@valpo.edu), and Henry Selkirk (NASA GSFC, Henry.B.Selkirk@nasa.gov)

PURPOSE: The workshop will provide a review of the state of TTL science, key questions, and measurement/analysis techniques. Discussion will focus on key science questions, as we try to understand how they map into upcoming observational campaigns, as well as how the campaigns can be coordinated. Participants include (a) topical experts, (b) students, and (c) investigators planning observational campaigns in the TTL. The agenda includes a mix of invited lectures, discussion, and synthesis of key science questions and observational strategies.

OVERVIEW OF THE AGENDA:

Day 1: TTL Structure: Past Observations and Historical Perspective
Day 2: Critical Outstanding TTL Questions
Day 3: Observational Plans for 2013 – 2015
Day 4: TTL Measurements and Modeling Mapped to Science Questions
Day 5: Coordination and Planning; Action Items and Future Work.

WORKSHOP PROCEEDINGS: Presenters develop not just their research presentations, but also (a) tutorial presentations with the background material necessary to understand the subject and (b) enhanced reference lists for future exploration of the presentation topics. Thus, each presentation will be archived as three documents: the tutorial, the references, and a video of the presentation itself. These documents will be collected as a "web book" on the TTL and made freely available using the Berkeley Press Digital Commons online server system, which can be found online at:

http://scholar.valpo.edu/ttlworkshop/

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MORE INFORMATION: See the conference website – http://physics.valpo.edu/TTLWorkshop

Daily Agenda

MONDAY: TTL Structure: Past Observations and Historical Perspective

Bus leaves hotel at 08:30. See page 24 for location of bus departure from hotel.

09:00 Introduction and logistics, motivation and scope of meeting
09:30 Introduction of participants
10:15 Group Photo & Break
10:45 **TTL Overview / Radiative Transfer**, *Andrew Gettelman*

11:45 LUNCH

13:00 **Cirrus Clouds and Convection in the TTL**, *Leonard Pfister*
14:00 **Water Vapor**, *William Randel*
15:00 Break
15:30 **TTL Transport & Wave Processes**, *Masatomo Fujiwara*
16:30 **Trace Species and Chemistry (Besides Water)**, *Anne Thompson*

Bus returns to hotel at 17:45

TUESDAY: Critical Outstanding TTL Questions

Bus leaves hotel at 08:30

09:00 **Stratospheric Dynamics (Including Waves)**, *Joan Alexander*
10:00 **In-Situ Aircraft Observations**, *Karen Rosenlof*
11:00 Break
11:30 **Ground Based Observations**, *Fumio Hasebe/Takashi Shibata*

12:30 LUNCH

13:30 **Satellite Observations**, *Masato Shiotani*
14:30 **Simulations (Idealized to Global)**, *Eric Jensen*
15:30 Break
16:00 **Data Assimilation**, *Kazuyuki Miyazaki*
17:00 Poster Introductions
17:30 Poster Session / Refreshments

Poster session abstracts can be found on page 8 of this program

Bus returns to hotel at 19:45

WEDNESDAY: Observational Plans for 2012-2015

Bus leaves hotel at 08:30

09:00 **Presentation of science questions**, *Organizing Committee*

Presentations by representatives for individual observational campaigns.
Each speaker will present (a) science questions, (b) key instruments and (c) locations and timing

Ongoing Project Foci

- 09:15 – **GRUAN**, *Holger Vömel* (Remotely)
- 09:30 – **NOAA**, *Dale Hurst*
- 09:45 – **Ticosonde**, *Henry Selkirk*
- 10:00 – **SHADOZ**, *Anne Thompson*
- 10:15 – **SOWER**, *Fumio Hasebe*

10:30 Break

Future Project Foci

- 11:00 – **ATTREX**, *Eric Jensen*
- 11:15 – **BATTREX**, *Joan Alexander/Anne Thompson/Gary Morris*
- 11:30 – **CAST–Aircraft**, *Neil Harris*
- 11:40 – **CAST–Sonde**, *Geraint Vaughan*
- 11:50 – **CONTRAST**, *Laura Pan*
- 12:00 – **AerOClim**, *Markus Rex*

12:20 Adjourn formal session

Bus returns to hotel at 12:30

Afternoon: Free for most participants.

For students: prepare synthesis presentations for Thursday in small groups.
More information on this session will be presented at the workshop.

THURSDAY: TTL Measurements and Modeling Mapped to Science Questions

Talk abstracts can be found on page 15 of this program

Bus leaves hotel at 08:30

09:00 **Quantifying the deep convective temperature signal within the tropical tropopause layer (TTL)**, *Thomas Birner*

09:20 **Cloud-top height dataset by geostationary satellite split window measurements trained with CLOUDSAT data**, *Noriyuki Nishi*

09:40 **Volatility and composition of TTL aerosols by balloon-borne in-situ observation**, *Masahiko Hayashi*

10:00 Break

10:30 **Impact of abrupt stratospheric dynamical change on Tropical Tropopause Layer**, *Nawo Eguchi, Kunihiko Kodera, and Tomoe Nasuno*

10:50 **Development of new HYdorometer VIdeo Sonde (HYVIS) system for ice cloud observation in TTL region**, *Kensaku Shimizu*

11:10 **In situ water vapor and ozone measurements in Lhasa and Kunming during the Asian summer monsoon**, *Jianchun Bian, Laura Pan, Laura Paulik, Holger Vömel, Hongbin Chen, and Daren Lu*

11:30 **The NOAA H_2O and O_3 data base**, *Karen Rosenlof*

11:50 **Ozone variations over the Northern subtropical region revealed by ozonesonde observations in Hanoi**, *Shin-ya Ogino*

12:10 **Identification of TTL boundaries using the ozone-water vapor relationship**, *Laura Pan*

12:30 LUNCH

13:30 **Summary of science questions from Monday – Wednesday**, *Talks led by student groups. 20 minutes per group on science topics.*

14:30 **Discussion of science questions**

15:00 Break

15:30 **Campaign Logistics, Mapping, and Discussion**, *presentation led by students*

16:30 **Plans for coordinated observations**

Workshop Dinner – more information to follow

Bus returns to hotel from restaurant after dinner

FRIDAY: Coordination and Planning; Action Items and Future Work

Bus leaves hotel at 08:30

09:00 **Discussion of synergies and where we can work together**

10:30 Break

11:00 **Discussion of observations, models and gaps: What's missing in current observation plans? Do campaigns, both scheduled and proposed, address the missing elements?**

11:30 **Review science questions and how coordinated observations help us to address them**

12:00 **Action items, common activities, and critical planning needs**

12:30 **End workshop**

Bus returns to hotel at 12:45

Afternoon: Organizing committee drafts white paper.

Tuesday's Poster Presentations with Abstracts

Poster titles and abstracts are listed alphabetically by the last name of the first author.

Correlated variability of upwelling and tracers near the tropical tropopause

Marta Abalos, Universidad Complutense de Madrid

Tropical upwelling should exert strong influence on temperatures and on tracers with large vertical gradients in the lower stratosphere. We test this behavior by comparing three upwelling estimates calculated from ERA-Interim reanalysis data with observed temperatures in the tropical lower stratosphere, and with measurements of ozone and carbon monoxide (CO) from the Aura Microwave Limb Sounder (MLS) satellite instrument. Time series of temperature, ozone and CO are well correlated in the tropical lower stratosphere, and we quantify the influence of tropical upwelling on this joint variability. Strong coherent annual cycles observed in each quantity are found to reflect the seasonal cycle in upwelling. Other contributions to the zonal mean tracer budgets are chemical production and loss and eddy mixing. We use data from the Whole Atmosphere Community Climate Model (WACCM) to investigate the seasonality and spatial structure of the different terms in the balances. Tropical upwelling, temperatures and tracers are significantly correlated also when isolating subseasonal timescales. This demonstrates the importance of upwelling in forcing transient variability in the lower tropical stratosphere.

The occurrence of thin cirrus clouds with 5-day waves over the tropical Indian Ocean during CINDY2011/DYNAMO

Jianchun Bian[1], Laura L. Pan[2], Laura Paulik[2], Holger Vömel[3], Hongbin Chen[1], and Daren Lu[1]

[1]Key Laboratory of Middle Atmosphere and Global Environment Observation (LAGEO), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

[2]National Center for Atmospheric Research, Boulder, Colorado, USA

[3]GRUAN Lead Center, Meteorologisches Observatorium, Lindenberg, Germany

Cirrus variability in association with 5-day waves is investigated using the shipboard a multi-wavelength high spectral resolution lidar system ($2\alpha+3\beta+2\delta$), Vaisala RS92 radiosondes at 3-hourly intervals, and 15 balloon-borne cryogenic Frostpoint hygrometers (CFH) in the tropical Indian Ocean (8.0^0S, 80.5^0E) during the Cooperative Indian Ocean experiment on intraseasonal variability in the Year 2011 (CINDY2011; the project name in the United States is Dynamics of the Madden-Julian Oscillation, DYNAMO) field campaign. Around the cold-point tropopause (CPT), 5-day waves with the vertical wavelength of ~5 km and the temperature amplitude of ~3 K were dominant during early November. Thin cirrus clouds appearance (disappearance) corresponded with the cold (warm) anomalies of the waves. Supersaturation (relative humidity with respect to ice; RHi > 100%) layers also co-existed with cold anomalies. Backward trajectories near the CPT showed the air parcels almost stayed over the vessel during this period. It is expected that the 5-day wave is important for a cirrus generation.

Cirrus and water vapor transport in the tropical tropopause layer: A modeling study

Tra Dinh, Princeton University

In simulations of tropical-tropopause-layer (TTL) cirrus forced by a large-scale equatorial Kelvin wave, we show that the radiatively induced mesoscale dynamics in these clouds actively contributes to vertical transport of water vapor. In a typical TTL cirrus, the heating that results from absorption of radiation by ice crystals induces a mesoscale circulation. Advection of water vapor by the radiatively induced circulation leads to upward advection of the cloudy air. Upward advection of the cloudy air is equivalent to upward transport of water vapor when the air above the cloud is drier than the cloudy air. On the other hand, ice nucleation and depositional growth, followed by sedimentation and sublimation lead to downward transport of water vapor. The net direction of transport is determined by the relative magnitudes of the upward advection of water vapor and the downward transport associated with microphysical processes.

The representation of the TTL in a tropical channel version of the WRF model.

Stephanie Evan, NOAA

In this study, the Weather Research Forecast (WRF) model is used to investigate key physical processes controlling the Tropical Tropopause Layer (TTL) temperature and water vapor distributions in December-January-February (DJF) 2006. The model domain is configured as a tropical channel with a horizontal grid-spacing of 37 km, a vertical grid-spacing of 500 m and a top at 0.1 hPa. Initial and boundary conditions are set using European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis Interim data. An ozone distribution computed from satellite and ozonesonde measurements is used for radiative forcing calculations. The model's ability to replicate observed TTL temperature variability is evaluated via comparisons with radiosonde data, the NASA Modern Era Reanalysis for Research and Applications (MERRA) and the ECMWF reanalyses. The Microwave Limb Sounder (MLS) water vapor measurements are used to evaluate WRF simulated water vapor in the TTL. Results of the simulations show that the model can well reproduce the mean temperature and its variability above 50 hPa as well as the tropical tropopause height in DJF. However, the model cold point tropopause temperature is colder than the reanalyses by ~1.2 K. The model captures the location of TTL water vapor minimum in the Western Pacific, although the model simulation is drier than the MLS observations in the TTL. To assess possible reasons for the tropopause temperature discrepancy, an additional WRF experiment was conducted using analysis nudging for water vapor only. The simulations with water vapor nudging show an increase in cloud ice of ~40% above 200 hPa, indicating more tropical cirrus clouds in the upper troposphere as well as a warming of ~1.5 K of the cold point tropopause. This suggests that the radiative effects of tropical cirrus clouds must be considered for accurate temperature simulations in the TTL.

Testing the role of radiation in determining tropical cloud top temperature

Bryce Harrop, University of Washington

Tropical anvil clouds that detrain near the mixing barrier near 13km in the tropics have a strong effect on the longwave and shortwave energy budgets of Earth. A cloud-resolving model is used to test the Fixed Anvil Temperature (FAT) Hypothesis proposed by *Hartmann and Larson* (2002). Results show that the radiative cooling, primarily due to water vapor, is the strongest control of the anvil cloud detrainment temperature. Water vapor concentrations are largely controlled by temperature, so, following the FAT hypothesis, the cloud detrainment should follow a fixed temperature. The results also show, however, that ozone contributes a significant heating rate in the upper tropical troposphere. If ozone is fixed as a function of pressure as the SST is warmed, anvil clouds warm and their fractional coverage decreases. The presence of a fixed ozone profile in our model can be thought of as a pressure dependent contribution to stability that inhibits convection from rising to the level of diminished water vapor cooling. This suggests that to model the response of tropical anvil clouds to climate change, one must also predict ozone in the upper tropical troposphere and TTL region, where ozone concentrations are also influenced by convection, forming a strong interaction between ozone and cold clouds in the tropics. Broader implications of the influence of the TTL on the detrainment temperature of tropical anvils include the modification of the longwave cloud radiative effect and the net radiative energy budget effect of tropical deep convective systems.

Dehydration in the TTL estimated from the water vapor match

Yoichi Inai, Tohoku University

The match method is applied to the quantification of the dehydration process in the tropical tropopause layer (TTL) over the western Pacific. The match pairs are sought from the Soundings of Ozone and Water in the Equatorial Region (SOWER) campaign network observations with the use of isentropic trajectories. For those pairs identified, extensive screening procedures are performed to verify the representativeness of the air parcel and the validity of the isentropic treatment and to check possible water injection by deep convection, consistency between the sonde data and analysis field, and conservation of the ozone content. Among those pairs remaining, we found some cases corresponding to the first quantitative value of dehydration associated with horizontal advection in the TTL. The statistical features on the dehydration for the air parcels advected in the lower TTL are derived from the match pairs. Match analysis indicates that ice nucleation starts before the relative humidity with respect to ice (RHice) reaches the value of $207 \pm 81\%$ (1σ) and that the air mass is dehydrated until the RHice reaches $83 \pm 30\%$ (1σ). The efficiency of dehydration is estimated as the relaxation time of the relative humidity for the supersaturated air parcel to approach the saturation state. This is empirically estimated from the match pairs as the quantity that reproduces the second water vapor observation given the first observed water vapor amount and the sequence of the saturation mixing ratio of the match air mass exposed during the advection. The relaxation time is found to range from 2 to 3 hours, which agrees with those reported from previous studies.

Constraining Middle Atmospheric Moisture in GEOS-5 Using EOS-MLS Observations

Jianjun Jin[1,2], Steven Pawson[2], Kris Wargan[2,3], Larry Coy[2,3], Meta Sienkiewicz[2,3]
[1]*USRA/Goddard Earth Sciences,Technology And Research (GESTAR)*
[2]*Global Modeling and Assimilation Office, NASA GSFC*
[3]*Science Systems and Applications International*

Middle atmospheric water vapor plays an important role in climate and atmospheric chemistry. In the middle atmosphere, water vapor, after ozone and carbon dioxide, is an important radiatively active gas that impacts climate forcing and the energy balance. It is also the source of the hydroxyl radical (OH) whose abundances affect ozone and other constituents. The abundance of water vapor in the middle atmosphere is determined by upward transport of dehydrated air through the tropical tropopause layer, by the middle atmospheric circulation, production by the photolysis of methane (CH_4), and other physical and chemical processes in the stratosphere and mesosphere. The Modern-Era Retrospective analysis for Research and Applications (MERRA) reanalysis with GEOS-5 did not assimilate any moisture observations in the middle atmosphere. It is planned to use such observations, available sporadically from research satellites, in future GEOS-5 reanalyses. This paper provides an overview of progress to date with assimilating the EOS-Aura Microwave Limb Sounder (MLS) moisture retrievals, alongside ozone and temperature, into GEOS-5. Initial results demonstrate that the MLS observations can improve the middle atmospheric moisture field in GEOS-5. Discussion will focus on how middle atmospheric moisture is assimilated and how Aura MLS moisture observations benefit the analyses.

On the turbulent mixing and ozone variations around the tropical tropopause associated with Kelvin waves

Kazunari Koishi, Kyoto University

The observed variations of ozone around the tropical tropopause layer in relation to large-scale waves both in the altitude and isentropic coordinates were examined by analyzing ozonesondes provided by SHADOZ (Southern Hemisphere Additional Ozonesondes). Because ozone near this level can be used for the tracer of atmospheric motion, we regarded an ozone enhancement as the signal of a turbulent mixing. Focusing on the vertical fine structure of ozone and temperature, this study presents observed variations of 10 stations near the equator. Based on the signals of Kelvin waves (an eastward-traveling component of equatorial waves) which is filtered in the spectral-frequency domain using reanalysis data (ERA-Interim), we clarified the dependency of the observed profiles to phase evolution of the large-scale wave. The details of relationships between ozone variations and waves will be presented in this poster.

Intraseasonal to interannual variations of the temperature structure around the tropical tropopause and their relationships with convective activities

Eriko Nishimoto, Kyoto University

Space-time variability in the tropical tropopause temperatures and its relationship with convective activities are examined by using the ERA40/ERA-interim re-analysis and NOAA/OLR data sets. Low temperatures around the tropical tropopause generally occur over the equator and extend northwestward and southwestward in the subtropics to form the horseshoe-shaped structure. This structure resembles a stationary wave response known as the Matsuno-Gill pattern, which is a superposition of the Rossby and Kelvin responses. Because of this, the two preliminary indices are first defined to represent the two responses. The horseshoe-shaped structure index is then calculated from the two indices. The seasonal and interannual variability in the horseshoe-shaped structure index is related to that observed in convective activities adjacent to three monsoon regions: the South Asian monsoon (SoAM) and the North Pacific monsoon (NPM) areas during the northern summer and the Australian monsoon area during the southern summer. The convective activities in the SoAM and NPM areas individually influence the horseshoe-shaped structure. During the southern summer the horseshoe-shaped structure index is also related to convective anomalies associated with the ENSO cycle and intraseasonal oscillation.

Atmospheric temperature tides in the tropical upper troposphere and lower stratosphere

Takatoshi Sakazaki, Hokkaido University

Atmospheric thermal tides are global-scale waves with periods that are harmonics of a solar day, mainly excited by diurnally varying diabatic heating in the troposphere and the stratosphere. Some recent studies suggested that the tidal temperature variations in the TTL might affect the appearance of cirrus clouds and, thus, the dehydration process. It should be noted, however, that the global pattern of diurnal temperature variations in the TTL still remains unclear. In this study, we aim at revealing the 3D structure of diurnal temperature variations around the TTL, including its seasonal variations, by using data from global reanalyses for the period of 2002-2006. It is found that the Sun synchronous tides have amplitudes of ~0.3 K (~0.5 K) at 100 hPa (70 hPa) in January. Superposed on these components, the non-Sun-synchronous tides are strong over the continent (South America, Africa); these may be excited by latent heat release associated with deep convections there. The total (i.e., Sun-synchronous plus non-Sun-synchronous) diurnal temperature amplitudes reach ~0.5 K (~1 K) at maxima at 100 hPa (70 hPa) in January. The seasonality and the impact on the dehydration will be discussed in the presentation.

Comparison between microphysical model simulation and observed cirrus clouds formation within a volcanic aerosol layer in the Tropical Tropopause Layer

Mayuko Sakurai, Nagoya University

In order to know the formation process of cirrus clouds in tropical tropopause layer, we used a microphysical numerical model to calculate nucleation and growing process of cirrus cloud particles, and compared the results of the model simulations with observed results. The observations compared had been performed at Biak, Indonesia in January 2011. Formation of cirrus clouds was observed by lidar in an aerosol layer at the altitude from 17.5 to 19 km. The backscatter coefficient of cirrus clouds was 10^{-8}~10^{-7}/m/str and number concentration was estimated less than $10^{5}/m^{3}$. Calculated results by model assumed only heterogeneous nucleation or only homogeneous nucleation (cooling rate < 0.1K/h) show agreements with the observed values. However, if there are solid and liquid aerosol particles, the simulations with heterogeneous nucleation show better agreement with the observation.

Development of a balloon-born Peltier-based chilled-mirror hygrometer for the troposphere and the lower stratosphere

Takuji Sugidachi, Hokkaido University

We have developed a new balloon-borne hygrometer, which is based on a chilled-mirror principle and uses a two stage Peltier cooler. In January 2012, we have conducted flight tests at Biak, Indonesia (1.18^{0}S, 136.11^{0}E) to evaluate the performances of this sensor. The result showed that this hygrometer has the ability to measure atmospheric water vapor from the surface to the lower stratosphere. It is considered that our hygrometer is helpful for TTL observation campaigns because of its ease-in-handling.

The occurrence of thin cirrus clouds with 5-day waves over the tropical Indian Ocean during CINDY2011/DYNAMO

Junko Suzuki, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Cirrus variability in association with 5-day waves is investigated using the shipboard a multi-wavelength high spectral resolution lidar system (2α+3β+2δ), Vaisala RS92 radiosondes at 3-hourly intervals, and 15 balloon-borne cryogenic Frostpoint hygrometers (CFH) in the tropical Indian Ocean (8.0^{0}S, 80.5^{0}E) during the Cooperative Indian Ocean experiment on intraseasonal variability in the year 2011 (CINDY2011; the project name in the United States is Dynamics of the Madden-Julian Oscillation, DYNAMO) field campaign. Around the cold-point tropopause (CPT), 5-day waves with the vertical wavelength of ~5 km and the temperature amplitude of ~3 K were dominant during early November. Thin cirrus clouds appearance (disappearance) corresponded with the cold (warm) anomalies of the waves. Supersaturation (relative humidity with respect to ice; RHi > 100 %) layers also co-existed with cold anomalies. Backward trajectories near the CPT showed the air parcels almost stayed over the vessel during this period. It is expected that the 5-day wave is important for a cirrus generation.

Analysis of the TTL cirrus and Their Convective Origin - A Water Perspective

Tao Wang and Andrew Dessler, Texas A&M University

Two mechanisms are thought to be primarily responsible for the formation of cirrus in the Tropical Tropopause Layer (TTL): detrainment from deep convective anvils and in situ initiation. By analyzing water vapor measurements from the Aura Microwave Limb Sounder (MLS) and ice water content measurements from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), we identify TTL cirrus that contain too much ice to have been formed in situ—and therefore must be of convective origin. Analyzing 3 years of CALIPSO measurements (2008–2010), we found three maxima in the occurrence of convective cirrus: equatorial Africa, the tropical western Pacific, and South America. Over the entire tropics, we found that convective cirrus occur more frequently during boreal winter-spring and less frequently during boreal summer-fall. The convective fractions of cirrus also increase until the cold-point tropopause is reached in most seasons—implying higher probabilities of cirrus around the tropopause being of convective origin. Averaged over 3 years, we find that at least ~30% of cirrus in the TTL are definitely of convective origin.

Water Vapor and Cloud Formation in the TTL: Simulation Results vs. Satellite Observations

Tao Wang[1], Andrew Dessler[1], and Mark Schoeberl[2]
[1]*Texas A&M University*
[2]*Science and Technology Corp.*

Driven by analyzed winds and temperature, domain-filling forward trajectory calculations are used to reproduce water vapor and cloud formations in the tropical tropopause layer (TTL). As with most Lagrangian models of this type, excess water vapor is instantaneously removed from the parcel to keep the relative humidity with respect to ice from exceeding a specified (super) saturation level. The dehydration occurrences serve as an indication of where and when cloud forms. Convective moistening through ice lofting and gravity waves are also included in our simulations as mechanisms that could affect water vapor abundances and cloud formations in the TTL. Our simulations produce water vapor mixing ratios close to that observed by the Aura Microwave Limb Sounder (MLS) and are consistent with the reanalysis tropical tropopause temperature biases, which proves the importance of the cold-point temperature to the water vapor abundances in the stratosphere. The simulation of cloud formation agrees with the patterns of cirrus distribution from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO). It proves that the trajectory calculations fed by the analyzed wind and temperature could produce reasonable simulations of water vapor and cloud formation in the TTL.

The Dehydration process in the Tropical Tropopause Layer

Moe Yamaki, Hokkaido University

Water vapor contributes to the radiation budget of earth and the photochemistry of ozone. Therefore, it is important to understand the variation of water vapor in the research of global warming and ozone depletion. Noting that the saturation water vapor mixing ratio in the Cold-Point Tropopause (CPT) is not always a good estimate of water amount entering the stratosphere, *Selkirk et al.* (2010) defined the Tropopause Saturation Layer (TSL) using the cryogenic frostpoint hygrometer data taken in the tropical eastern Pacific during Northern Hemisphere summer. In the present study, the effectiveness of TSL is examined by using the SOWER data taken in the tropical western Pacific during Northern Hemisphere winter. The contribution of waves associated with the intraseasonal oscillation to dehydration will be discussed along with that of the seasonal variation in the TTL. The results will be reported at poster presentation.

Thursday's Oral Presentations with Abstracts

Quantifying the deep convective temperature signal within the tropical tropopause layer (TTL)

Thomas Birner, Department of Atmospheric Science, Colorado State University

Dynamics on a vast range of spatial and temporal scales, from individual convective plumes to planetary-scale circulations, play a role in driving the temperature variability in the tropical tropopause layer (TTL). Here, we aim to better quantify the deep convective temperature signal within the TTL using multiple datasets. First, we investigate the link between ozone and temperature in the TTL using the Southern Hemisphere Additional Ozonesondes (SHADOZ) dataset. Low ozone concentrations in the TTL are indicative of deep convective transport from the boundary layer. We confirm the usefulness of ozone as an indicator of deep convection by identifying a typical temperature signal associated with reduced ozone events: mid and upper tropospheric warming and TTL cooling. We quantify these temperature signals using two diagnostics: 1) the "ozone minimum" diagnostic, which has been used in previous studies and identifies the upper tropospheric minimum ozone concentration as a proxy for the level of main convective outflow; and 2) the "ozone mixing height", which we introduce in order to identify the maximum altitude in a vertical ozone profile up to which reduced ozone concentrations, typical of transport from the boundary layer are observed. Results indicate that the ozone mixing height diagnostic better separates profiles with convective influence than the ozone minimum diagnostic. Next, we collocate deep convective clouds identified by CloudSat 2B-CLDCLASS with COSMIC GPS temperature profiles. We find a robust large-scale deep convective TTL temperature signal that is persistent in time. However, it is only the convective events that penetrate into the upper half of the TTL that have a significant impact on TTL temperature. A distinct seasonal difference in the spatial scale and the persistence of the temperature signal is identified. Deep-convective cloud top heights are found to be well described by the level of neutral buoyancy.

Cloud-Top Height Dataset by Geostationary Satellite Split Window Measurements Trained with Cloudsat Data

Noriyuki Nishi, Kyoto University

Lookup tables for estimating the cloud-top height (CTOP) and visible optical thickness of upper-tropospheric clouds by the infrared brightness temperature (TB) at 10.8 µm (T11) and its difference from TB at 12 µm (DT11-12) measured by geostationary satellites are developed (*Hamada and Nishi* 2010, JAMC). These lookup tables were constructed by regressing the cloud radar measurements by the CloudSat satellite over the infrared measurements by the Japanese geostationary multifunctional transport satellite MTSAT-1R and MTSAT-2. The CTOP is available at

http://database.rish.kyoto-u.ac.jp/arch/ctop/

since July 2005. The data have good precision for cirrus clouds ($\tau > \sim 3$) that have large DT11-12 values and are suitable for analyses of cloud systems with well-developed cirrus clouds. We made correction for the satellite view angle and can offer the data over almost all tropical regions where the satellites can observe (20S-20N, 80E-160W for MTSAT-1R and 85E-155W for MTSAT-2).

Volatility and composition of TTL aerosols by balloon-borne in-situ observation

Masahiko Hayashi, Fukuoka University

Tandem optical particle counters (OPC) were launched by balloon, from Biak 1^0S, 136^0E in January 2011 and 2012. One of the tandem OPC directly observed size distribution of aerosols of 0.3 – 7 μm in diameter, and another one observed size distributions in heated conditions of 100^0, 150^0, and 200^0C through thermodenuder, to observe volatility of TTL aerosols. Most of TTL aerosol smaller than 0.8 μm in diameter show high volatility, suggesting to be composed of sulfuric acid or sulfate. There also exist non-volatile particles larger than 0.8 μm in diameter, suggesting a composition of sea salt or volcanic ash. Number concentrations of non-volatile aerosol are similar to those of cloud particles in TTL.

Impact of abrupt stratospheric dynamical change on Tropical Tropopause Layer

Nawo Eguchi[1], Kunihiko Kodera[2], and Tomoe Nasuno[3]
[1]Research Institute for Applied Mechanics (RIAM), Kyushu University, Kasuga, Japan.
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We have studied the impact of stratospheric circulation change on water vapor in the Tropical Tropopause Layer (TTL) during the stratospheric sudden warming (SSW) events (e.g., *Eguchi and Kodera*, 2010). Increased Brewer-Dobson circulation associated with SSW produces cooling in the tropical lower stratosphere (LS). The cooling generally produces more cirrus clouds and decreases of the water vapor mixing ratio (WV) in the TTL, except for some regions over Africa and South American continents where penetrating clouds are expected. This time, we found a new stratospheric phenomenon which produces abrupt warming in the tropical stratosphere converse to the SSW event. The dynamical aspect of this phenomenon and the impact on the convective activity will be discussed. Due to the interaction between the subtropical jet and polar night jet in the upper stratosphere, tropical stratosphere warmed about two weeks in early December 2011. Accordingly, temperature in the TTL suddenly increased (approximately 0.5 K at 100 hPa) and the tropical convection ceased. Further, the downward velocity anomaly appeared from stratosphere to lower troposphere through the TTL. The present study mainly focuses on the variation of WV, temperature and cirrus clouds in the upper troposphere (UT) and LS in the period of the stratospheric dynamical change. The data from EOS MLS (Earth Observing System, Microwave Limb Sounder) is used. Before the start of abrupt warming event, the tropical convection temporarily enhanced at the south of the Equator. Then the temperature in the TTL decreased with the Kelvin wave like vertical structure: the WV at 146 hPa increased, while the WV at 100 hPa decreased, and the dryer air extended to 83 hPa with a few days lag. Following the start of the warming event, the tropical convection was suppressed. In the UT and LS, the warm and wet tendencies were found in the temperature and WV anomalies from seasonal march, respectively, and the ice cloud suddenly disappeared with increasing temperature, suggesting adiabatic heating. The result found of the present study clearly shows that the stratospheric dynamical change controls the WV variation in the UT and LS, as well as the tropical convection.

Development of new HYVIS system for ice cloud observation at TTL region

Kensaku Shimizu, Meisei Electric Co., Ltd

Cirrus clouds in the TTL play an important role on the radiation budget and thus the understanding of their optical properties together with the microphysical processes associated with their formation is quite important. In spite of the progress in theoretical research on the TTL cirrus (e.g., *Koop et al.*, 2000; *Peter et al.*, 2006), observational research is not enough because of the difficulty due to its height and coldness. On the other hand, research of cirrus clouds at 10 km height has been carried out since 1990s using aircraft and hydrometer sondes such as HYVIS (*Murakami and Orikasa*, 1997) and Replicator (*Miloshevich and Heymsfield*, 1996). As the Replicator collects replica particles on onboard films, it must be recovered after observation, which makes it rather difficult to apply to the TTL observations. On the other hand, HYVIS that transmits video picture to the ground station could be readily applied for the TTL if high-resolution monitoring is available. This presentation introduces newly refined HYVIS suitable for TTL observation and demonstrates the preliminary results obtained from the observations conducted in the subtropical region Okinawa in June 2012.

In Situ Water Vapor and Ozone Measurements in Lhasa and Kunming during the Asian Summer Monsoon

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Asian summer monsoon (ASM) anticyclone circulation is recognized to be a significant transport pathway for water vapor and pollutants to enter the stratosphere. Observational evidence, however, is largely based on satellite retrievals. We report the first coincident in situ measurements of water vapor and ozone within the ASM anticyclone. The combined water vapor and ozone sondes were launched from Kunming in August 2009 and Lhasa in August 2010. We present the key characteristics of these measurements, and provide a comparison to similar measurements from Alajuela, Costa Rica, an equatorial location, during the Tropical Composition, Cloud and Climate Coupling (TC4) campaign in July and August 2007. Results show that the ASM anticyclone region has higher water vapor and lower ozone concentrations in the upper troposphere and lower stratosphere than the TC4 observations. The results also show that the cold point tropopause in the ASM region has a higher average height and potential temperature. In situ observations therefore support satellite-based conclusions. The data also provide additional details on the vertical structure of the region in and around the anticyclone.

In-SituAircraft Observations

Karen Rosenlof, NOAA

Vertical profiles of humidity and ozone from the upper troposphere to stratosphere have been retrieved from several different limb sounding and solar occultation satellite instruments since the 1980’s. Instruments retrieving water vapor include the SAGE and POAM instruments, UARS MLS, UARS HALOE, and more recently, ACE-FTS and Aura MLS. Here, I will present ongoing work aimed at combining these measurements into a geographically gridded data set that can be used for quantifying variability and long-term changes in water vapor and ozone, and also for assessing the radiative impact of changes in upper tropospheric and stratospheric humidity.

Ozone variations over the Northern subtropical region revealed by ozonesonde observations in Hanoi

Shin-Ya Ogino, Japan Agency for Marine-Earth Science and Technology

Seasonal and subseasonal variations in the ozone mixing ratio (OMR) are investigated by using continuous seven-year ozonesonde data from Hanoi (21^0N, 106^0E), Vietnam. The mean seasonal variations for the seven years show large amplitude at the upper troposphere and lower stratosphere (UTLS) region (10–18 km) and at the lower troposphere (around 3 km) with standard deviations relative to the mean value of about 30% for both regions. In the UTLS region, the seasonal variation in the OMR shows a minimum in winter and a maximum in spring to summer. The variation seems to be caused by the seasonal change in horizontal transport. Low OMR air masses are transported from the equatorial troposphere in winter by the anti-cyclonic flow associated with the equatorial convections, and high OMR air masses are transported from the mid-latitude stratosphere in summer possibly due to tropopause foldings in the UT region and anti-cyclonic circulation associated with the Tibetan High in the LT region. In the lower troposphere, a spring maximum is found at 3 km height. Biomass burning and tropopause foldings are suggested as possible causes of this maximum. Subseasonal variations in the OMR show large amplitude in the UTLS region (at around 15 km) and in the boundary layer (below 1 km) with the relative standard deviations larger than 40%. The OMR variations in the winter UTLS region have a negative correlation with the meridional wind. This relation indicates that the low OMRs observed at Hanoi have been transported from the equatorial region.

Identification of TTL Boundaries using the Ozone–Water Vapor Relationship

Laura Pan, National Center for Atmospheric Research

Two sets of TTL boundary definitions have been proposed in the literature. One uses the static stability structure (*Gettelman and Foster*, 2002) and the other uses the radiative forcing mass flux criterion (*Fu et al.*, 2007; *Fueglistaler et al.*, 2009). In this work, we present a method to characterize the TTL boundaries using ozone–water vapor relationship. The result shows that the tracer behavior supports the level of the minimum stability to be the lower boundary of the transition layer and the cold point to be a good proxy of the upper boundary. Using this method, we characterize and compare the behavior of the tropopause transition layer in the Asian summer monsoon region and that of the deep tropics. The Asian summer monsoon region has been known to behave similarly to the TTL in its very high convectively driven tropopause and potentially is an alternative transport pathway for water vapor transport into stratosphere. The comparison between observations in the Asian summer monsoon region (Kunming and Lhasa, China, ~ 25^0N and 30^0N, respectively) and the equatorial TTL (Alajuela, Costa Rica, ~10^0N) shows that the transition layer in the Asian monsoon region is narrower but at higher potential energy levels compared to that observed in the Central American measurements. The possible applications of this method to understanding the global TTL structure will be discussed.

Local Information for Your Stay in Honolulu, Hawaii

Arrival

From Honolulu International Airport (HNL) to the Ala Moana hotel is about 8 miles (13 kilometers). You can get a taxi (there are official taxi dispatchers in yellow shirts) which should take 15–20 minutes and cost about $40. There are cheaper shuttle services which take several people to a number of hotels including the Ala Moana Hotel and cost about $15. If you have confidence your flight will arrive on time you can even make a reservation in advance on this one

http://www.airportwaikikishuttle.com/

The Ala Moana Hotel, 410 Atkinson Drive, is located just outside the famous Waikiki neighborhood and directly across the street from the Ala Moana Shopping Center. Ala Moana means “path by the ocean” in the Hawaiian language.

Near the Hotel

The ocean and Ala Moana Beach Park are just on the other side of the shopping center. You can access the shopping center directly from the second floor of the hotel.

Ala Moana Shopping Center (http://alamoanacenter.com/) is the largest shopping center within 2000 miles (3200 kilometers)! It has many shopping and dining options.

Getting to the Meeting

The bus will leave at 08:30 each morning from outside the hotel (around the corner from the main entrance – see bottom map on page 21).

The meeting is at the “Imin Conference Center” which is in “Jefferson Hall” which is one of the buildings at the “East-West Center”. If you miss the conference bus you should be able to get a taxi from the hotel to “Jefferson Hall at the East-West Center” for about $10 – $15. There is also the local city bus number 6 (see below) that goes between the hotel and East-West Center. Finally, you can walk, but it would take about an hour to walk from the hotel to the meeting, and it would not be a very pleasant walk as it would be mainly along busy streets. The top map page 21 shows the location of the hotel and meeting.

Getting Around

You should be able to get to the meeting on the conference bus. There are lots of dining options, shopping, and beaches within walking distance of the hotel. The city bus can take you to attractions downtown and near the city. However, if you want to get into the areas outside of Honolulu, you will need to rent a car.

Local City Bus

For the Honolulu local bus service you can get details at http://thebus.org. You will need $2.50 exact change to ride the city bus. Bus number 6 runs between the Ala Moana shopping center and the University of Hawaii campus and East-West Center.

Car Rental

Even after you are here, it should be easy to rent a car for as short as a single day and pick it up at or near the hotel. Check with the hotel concierge desk for details.

Weather

The long-term weather averages at the Honolulu airport for the month of October are:

Daily max temperature:	87^{0}F (30.5^{0}C)
Daily min temperature:	73^{0}F (22.7^{0}C)
Monthly rainfall total:	2.7 inches (6.8 cm)
Average number of rainy days in October:	7.6

The meeting location is rainier than the airport, however.

** BRING AN UMBRELLA **

For the sunny times a hat and sunglasses are advisable.

Up to date weather info for Hawaii including forecasts and satellite and Doppler radar animations are collected at

http://weather.hawaii.edu

Local Attractions and Activities

There are many worthwhile attractions and activities in Honolulu and outside the city on the island of O'ahu. Here's one reasonably organized site describing some of the well known attractions

http://www.gohawaii.com/oahu/plan-a-trip/activities/attractions

The hotel concierge desk will be able provide lots more information and can help you to arrange visitor activities of various kinds from surfing lessons to bus tours.

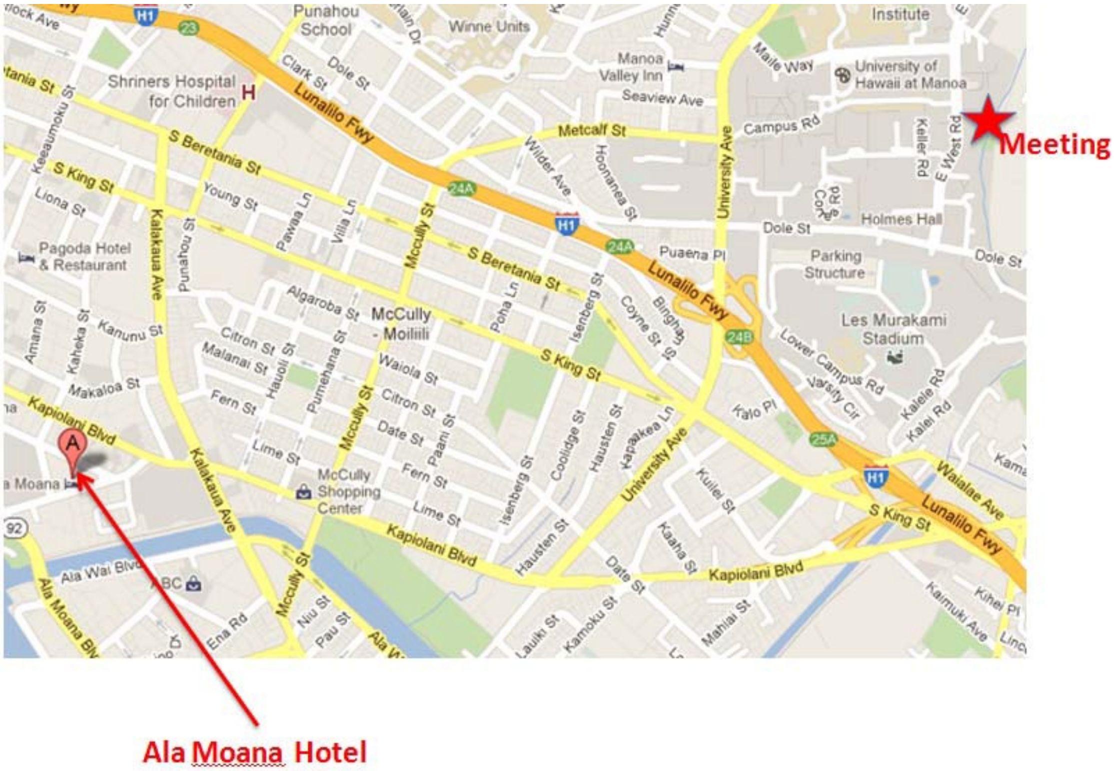
Hawaii

Hawaii is an unusual place in terms of geology, ecology, history and culture and you may want to do some background reading before you come. The "Hawaii" Wikipedia page is a pretty good concise introduction:

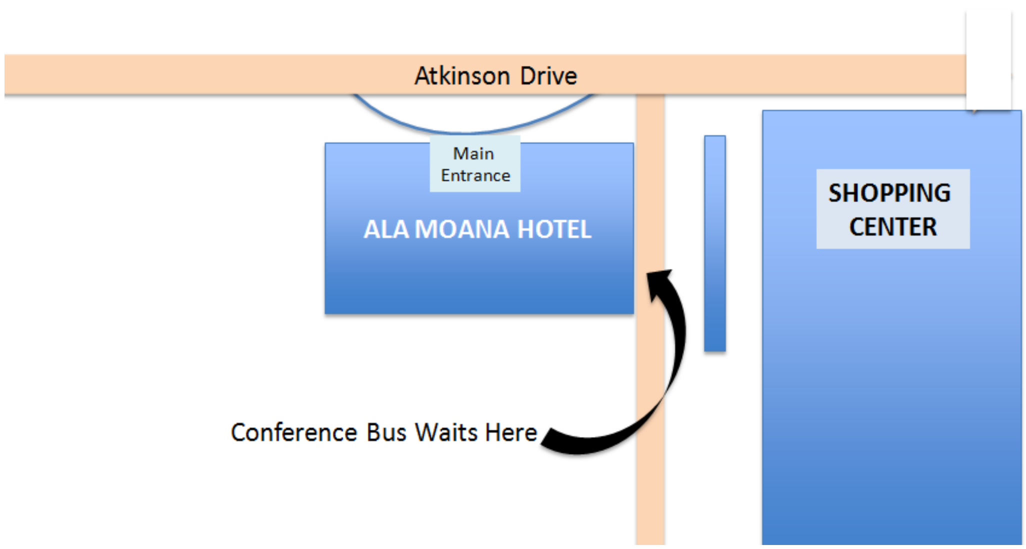
http://en.wikipedia.org/wiki/Hawaii

Many Hawaiian language words are used in everyday English conversation here

http://hawaiian-words.com/common/



The bus should be waiting around the side of the hotel as shown below.



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