초 록 집

Program & Abstracts

2017년 6월 27일(화) ~ 6월 29일(목)
한국해양과학기술원 제주국제해양과학연구·지원센터

주최 : 한국수리생물학회 (KSMB)
주관 : 한국해양과학기술원 제주국제해양과학연구·지원센터
<table>
<thead>
<tr>
<th>시간</th>
<th>세션 및 내용</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00</td>
<td>Registration</td>
</tr>
<tr>
<td>14:00-14:20</td>
<td>Greeting &amp; Opening Remarks: (KSMB 회장)</td>
</tr>
<tr>
<td>14:20-15:10</td>
<td>Plenary Talk I: Responses of phytoplankton functional types to changing winter vertical mixing and atmospheric deposition: a modeling study (유신재)</td>
</tr>
<tr>
<td>15:10-15:30</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>15:30-17:30</td>
<td>Session A1: Application of mathematical biology in ocean and fisheries sciences (좌장: 정석근)</td>
</tr>
<tr>
<td>①</td>
<td>Estimation of the potential fisheries production in the Korean waters with satellite-derived-ocean-color data (고성길)</td>
</tr>
<tr>
<td>②</td>
<td>Impact of Three Gorges Dam on primary productivity in the East China Sea (공은진)</td>
</tr>
<tr>
<td>③</td>
<td>Environmental predictors of habitat suitability and spatial distribution of Indo-Pacific bottlenose dolphin (<em>Tursiops aduncus</em>) in Jeju waters (안소언)</td>
</tr>
<tr>
<td>④</td>
<td>Neural network algorithms for detecting <em>Cochlodinium polykrikoides</em> blooms (유신재)</td>
</tr>
<tr>
<td>⑤</td>
<td>Simulation-based Yield-per-recruit Analysis of Pacific anchovy <em>Engraulis japonicas</em> in the Southern Sea of Korea (이경환)</td>
</tr>
<tr>
<td>⑥</td>
<td>Optimal harvest strategies based on a stage-structured model for sandfish in the East Sea (조기필)</td>
</tr>
<tr>
<td>15:30-17:30</td>
<td>Session A2: 빅데이터와 동물질병 관리 (좌장: 박홍식)</td>
</tr>
<tr>
<td>①</td>
<td>mBird, Wild Bird Movement Visualization Web Site (정우석)</td>
</tr>
<tr>
<td>②</td>
<td>Understand Current Issues on the Foot-and-Mouth Diseases: Role of Mathematic Models (윤하정)</td>
</tr>
<tr>
<td>③</td>
<td>Big Data Machine Learning Risk Assessment on Highly Pathogenic Avian Influenza (HPAI) for Poultry Farms (이원진)</td>
</tr>
<tr>
<td>17:40-20:00</td>
<td>Banquet(뷔페)</td>
</tr>
<tr>
<td>시간</td>
<td>세션 내용</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>09:00-10:00</td>
<td><strong>Tutorial Session: Mathematical Modeling of Biological Systems</strong> (강사: 김정은)</td>
</tr>
<tr>
<td>10:00-12:00</td>
<td><strong>Session B1: 심포지엄: 생태계 교란 평가를 위한 생태모델링</strong> (최장: 박영석)</td>
</tr>
<tr>
<td>①</td>
<td>Determining the environmental factors to pattern ETP endemic species in Korea (배미정)</td>
</tr>
<tr>
<td>②</td>
<td>기후변화에 따른 왕우렁이(Pomacea canaliculata)의 잠재적 서식지 예측 (이대성)</td>
</tr>
<tr>
<td>③</td>
<td>Changes of benthic macroinvertebrate community composition following summer precipitation using self-organizing map (홍철)</td>
</tr>
<tr>
<td>④</td>
<td>환경교란이 하천의 잠자리목 군집 변화에 미치는 영향 예측 (이다영)</td>
</tr>
<tr>
<td>⑤</td>
<td>하천에 서식하는 맥점벌레목의 다양성에 미치는 환경인자 특성 분석 (문미영)</td>
</tr>
<tr>
<td>10:00-12:00</td>
<td><strong>Session B2: Stochastic Fluctuations in Biological Circuits</strong> (좌장: 김철민)</td>
</tr>
<tr>
<td>①</td>
<td>Chemical fluctuation theorem for vibrant enzyme networks in living cells (성재영)</td>
</tr>
<tr>
<td>②</td>
<td>An Artificial Hair cell Modeling: Characteristics and mechanisms of a hair cell (송태근)</td>
</tr>
<tr>
<td>③</td>
<td>Mathematical Modeling of Glucose Homeostasis (조정효)</td>
</tr>
<tr>
<td>10:00-12:00</td>
<td><strong>Session B3: Infectious Disease Modeling and Diffusion</strong> (좌장: 이창형)</td>
</tr>
<tr>
<td>①</td>
<td>Modeling human mobility in two-patch epidemic models (이선미)</td>
</tr>
<tr>
<td>②</td>
<td>Modeling the Impact of Climate Change on Dengue Fever Incidence in Korea (이효정)</td>
</tr>
<tr>
<td>③</td>
<td>The role of spatial transmission and control measures in the avian influenza epidemic 2016-2017 in Korea (이종경)</td>
</tr>
<tr>
<td>④</td>
<td>On the Dynamics of Predator-prey Systems with a Functional Response Describing Predator Grouping (고원률)</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch (구내식당)</td>
</tr>
<tr>
<td>13:00-13:50</td>
<td><strong>Poster Session</strong></td>
</tr>
<tr>
<td>①</td>
<td>A Mathematical model of money’s circadian rhythm for developing a new drug (김대욱)</td>
</tr>
<tr>
<td>②</td>
<td>Comparison of Two Types of Gene Repression in a Circadian Clock (정의민)</td>
</tr>
<tr>
<td>③</td>
<td>Control strategies for rumor spreading depending on interest level of rumor (정용담)</td>
</tr>
<tr>
<td>④</td>
<td>A theoretical study on mathematical modelling of MERS-Cov transmission with application of optimal control (이동호)</td>
</tr>
<tr>
<td>⑤</td>
<td>A spatial SIS epidemic model with risk-induced dispersal (최원형)</td>
</tr>
<tr>
<td>⑥</td>
<td>Epidemic Model of Foot-and-Mouth Disease with Vaccine (최용인)</td>
</tr>
<tr>
<td>⑦</td>
<td>Does movement toward better environment always benefit biological species? (김광중)</td>
</tr>
</tbody>
</table>
13:50-14:00  Coffee Break

14:00-14:50  Plenary Talk II: Mathematical Models for the Life Sciences
(정일효)

14:50-15:10  총회 및 포스터 시상식

15:10-15:30  Coffee Break

15:30-17:30  Session C1: 기후변화 영향평가를 위한 RCP 기반 기후변화 응용정보
생산 (좌장: 정일효)
① 기후변화 영향평가를 위한 RCP 시나리오 기반 행정구역별 기후자료 산출 (김성찬)
② RCP 시나리오에 따른 미래 All (Simple Aridity Intensity Index) 변화와 식물분포에 미치는
영향 (이솔기)
③ 기후변화 영향평가를 위한 RCP 시나리오 기반 Oi (Ombrothermic Index) 생산 및 양서파충
류 변화상 예측 (이주현)
④ Analysis the dispersion of raining day-rainfall with RCP scenario in Korea (박재록)

15:30-17:30  Session C2: General Session (좌장: 이완호)
① GMO 유전자를 갖는 옥수수의 천이 분석 (진홍성)
② A microscale model of bacterial flagella motility (이완호)
③ Mathematical model for contractile ring-driven cytokinesis using IB and PF methods
(이승규)
④ The change of TGI and total payloads in tumor cells according to linker stability: What
are the better strategies either the linker or the payload improvement? (변종혁)

6월 29일 (목)

10:00-11:00  Tutorial Session: Stochastic Modeling in Epidemiology
(강사: 김정은)
Plenary Talk I

Responses of phytoplankton functional types to changing winter vertical mixing and atmospheric deposition: a modeling study

Sinjae Yoo and Soonmi Lee

1 Jeju International Marine Science Center for Research & Education, KIOST, South Korea

2 Ocean Science and Technology School, Korea Maritime and Ocean University/Korea Institute of Ocean and Science Technology Joint Program, Busan, South Korea

sjyoo@kiost.ac.kr

Using the zero-dimensional European Regional Seas Ecosystem Model (ERSEM) for 2001-2012, we investigated the impacts of varying winter vertical mixing and atmospheric deposition on the lower trophic level ecosystem in the Ulleung Basin, East Sea[1]. The model results show that as the winter maximum mixed layer depth (MMLD) changes, the growth and grazing loss of phytoplankton functional types (PFTs) are affected differently resulting in an altered succession process of PFTs in the upper mixed layer. Diatoms preempt the early spring growth by better utilization of light and nitrate. Diatoms’ advantages lessen as MMLD decreases. Flagellates and picophytoplankton show mixed responses to decreased MMLD. Their net primary productivity (NPP) and peak biomass decrease but their annual biomass increases due to decreased grazing. Dinoflagellates are always doing better when MMLD decreases. The model results also indicate that with an increase in atmospheric deposition, the picophytoplankton and the flagellates increased in summer, whereas the dinoflagellates and the diatoms decreased. For the study period, the atmospheric deposition in the Ulleung Basin increased the annual net primary production by 4.58% (mean; range 3.77–10.58%). Taking the results together, it is likely that as the warming and atmospheric deposition continue to intensify into the future, the phytoplankton community in the region will shift to smaller phytoplankton with consequent changes of food web structure to follow.

REFERENCES

Plenary Talk II

Mathematical Models for the Life Sciences

Il Hyo Jung

Department of Mathematics, Pusan National University
Busan 46241, KOREA
ilhjung@pusan.ac.kr

The aim of this talk is to introduce several mathematical models in the life sciences and construct an integrated pest management model by using mathematical modelling as one of them. The pest management model involves some appropriate tactics from a range of pest control techniques including biological and chemical methods to suit individual systems, pest complexes and local environments. In particular, the sterile insect technique, which is one of the effective biological control for pests is given. We apply this technique to the management problem to control pest populations.

REFERENCES

Special Sessions
Session A1

Application of mathematical biology in ocean and fisheries sciences

Organizer: 정석근 (제주대학교)

Date/Time: 6월 27일(화) 15:30

Speakers:

1. 고성길 (제주대학교)
2. 공은진 (한국해양과학기술원)
3. 안소언 (한국해양과학기술원)
4. 유신재 (한국해양과학기술원)
5. 이경환 (제주대학교)
6. 조기필 (부산대학교)
Estimation of the potential fisheries production in the Korean waters with satellite-derived-ocean-color data

Seonggil Go and Sukgeun Jung

Department of Marine Life Sciences, College of Ocean Sciences, Jeju National University (JNU), Jeju
Seonggil117@gmail.com

In 2016, the annual catch from the Republic of Korea's marine-capture fisheries has dropped below one million ton for the first time in 44 years. So, urging policy makers and fisheries scientist to estimate the sustainable fisheries production. To estimate the potential fisheries production, we utilized the ocean-color data from the Geostationary Ocean Color Imager (GOCI). Using the GOCI data in 2014, we constructed the biomass size spectrum (BSS) for phytoplankton by size(micro-20～200μm, nano-2～20μm, pico-0.2～2μm). To estimate the potential production of the fishery resource in the Korean coastal waters based on biomass size-spectrum model to be 530 million tons per year, approximately. In addition, we estimated the potential fisheries production based on the Ryther’s(1969) ecosystem method to be 250 million tons per year.
Impact of Three Gorges Dam on primary productivity in the East China Sea

Christina Eunjin Kong\textsuperscript{1}, Sinjae Yoo\textsuperscript{1,2}, and Chan Joo Jang\textsuperscript{1,2}

\textsuperscript{1}Ocean Science and Technology School, Busan, Republic of Korea.
\textsuperscript{2}Korea Institute of Ocean Science and Technology, Ahnsan, Republic of Korea

cejkong@kiost.ac.kr

The Three Gorges Dam (TGD) on the Changjiang (Yangtze) river is the world’s largest hydropower project which began operating in June 2003. Many researchers have been concerned with the potential impact of the TGD on the adjacent marine ecosystem. For instance, Gong et al. (2006) argued that this massive dam may cause reduction in marine primary productivity in ECS by changing the supply of nutrients and sediment discharge in the area. In this study, we examined the long-term spatial and temporal trend of marine primary productivity (PP), chlorophyll-a (CHL), photosynthetically active radiation (PAR), sea surface temperature (SST) and euphotic depth (Zeu) of the ECS during last two decades (1998-2014). We also compared the cross correlation between the anomalies of Changjiang River discharge (CRD) and chlorophyll during pre-TGD (1998-2002) and post-TGD (2003-2007) to understand the sensitivity of the change and some potential influence of the ECS productivity. Our results suggest that the geographic extent of CRD influence was indeed greatly reduced after 2003. However, the large scale variability of the primary productivity did not show any correlation with the operation of the TGD nor show clear temporal and spatial trend in the ECS. Therefore, we conclude that the TGD has not reduced the primary productivity of the East China Sea as a whole.

REFERENCES

Environmental predictors of habitat suitability and spatial distribution of Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) in Jeju waters

안소언 1, 유신재 1, 김현우 2

1 한국해양과학기술원, 2 고래연구센터, 국립수산과학원

The Indo-Pacific bottlenose dolphin population in Jeju waters is resident in the region and its size is estimated to 100-110 individuals. To conserve this endangered species, the urgent challenge is to understand their habitat range and habitat preference well enough to maintain this population in the face of the pressures resulting from environmental changes. The aim of this study is to use species distribution models to investigate the distribution of *Tursiops aduncus* and the effects of environmental variables on the habitat suitability of this species. We compiled interannual dataset (2004-2016) comprised of annual cetacean sighting data from Cetacean Research Institute and from Jeju University. We selected environmental variables such as mean SST, salinity, pH and water depth which are likely to be primary drivers for dolphin distribution and these were obtained from Bio-Oracle global environmental data packages (5 arcmin) and the General Bathymetric Chart of the Oceans (GEBCO). The result indicated that the distribution of Indo-Pacific bottlenose dolphin was influenced by water depth and the area of northern part of Jeju coast waters was predicted to be a highly suitable habitat. Maxent model generated for *Tursiops aduncus* returned the area under the ROC curve (AUC) values higher than 0.9.
Neural network algorithms for detecting 
*Cochlodinium polykrikoides* blooms

Sinjae Yoo\(^1,2\), Yeseul Kim\(^1,2\) and Young Baek Son\(^1\)

\(^1\) Jeju International Marine Science Center for Research & Education, KIOST, South Korea

\(^2\) Ocean Science and Technology School, Korea Maritime and Ocean University/Korea Institute of Ocean and Science Technology Joint Program, Busan, South Korea

sjyoo@kiost.ac.kr

This study is to develop detection algorithms for the blooms of *Cochlodinium polykrikoides*, which has caused serious HABs for more than two decades in Korean waters. Various algorithms have been proposed to detect HABs. However, most of those algorithms are empirical and therefore limited in their applicability in the coastal areas where bio-optical conditions are highly variable spatially and temporally. In a previous study\([1]\), we have shown that remote sensing reflectance of *Cochlodinium polykrikoides* exhibit a distinctive depression in the blue-green wavelength band based on a large data set of remote sensing reflectance simulated using HydroLight and IOCCG data. We also showed that *Cochlodinium polykrikoides* can be clearly separated from unspecified phytoplankton assemblages in the two waveband ratio space \((R_{\text{rs}}(555)/R_{\text{rs}}(531), R_{\text{rs}}(488)/R_{\text{rs}}(443))\). Based on this, we are developing neural network algorithms for in-water and satellite applications. Our preliminary test using simulated and satellite data shows that the success rate of the in-water algorithm ranges from 71.6% \((\text{chl-}a > 5 \text{ mg m}^{-3})\) to 89.8% \((\text{chl-}a > 30 \text{ mg m}^{-3})\). We also compare the performance of neural network algorithms for satellite data.

**REFERENCES**

Simulation-based Yield-per-recruit Analysis of Pacific anchovy

*Engraulis japonicas* in the Southern Sea of Korea

Kyunghwan Lee, Seonggil Go and Sukgeun Jung

*Department of Marin Life Science, Jeju National University, Jeju 63243, Korea*

Kyunghwan034@gmail.com

Commercial catch of Pacific anchovy (*Engraulis japonicus*) in Korean coastal waters has steadily increased since the 1950’s. To evaluate consequences of fishing activities on anchovy production and economic yield, we undertook daily simulations for the yield-per-recruit (Y/R) analysis by applying the derived growth function and size-dependent natural mortality. We evaluated consequences of changes in fishing activity by varying: 1) instantaneous fishing mortality, 2) the length at first capture (Lc) depending on different fishing types: 1) To protect larva and juvenile stage stock (catch≥80 mm, FL), 2) To protect adult stage stock (catch≤80 mm, FL). Outcomes of Y/R analysis by varying Lc suggested that potential yield could be maximized when Lc ranges between 42-60 mm at protecting adult stage stock and 88-160 mm fork length (FL) at protecting larvae and juvenile stage stock. At 30 mm (Lc) at first catch length, the estimated result of economic yield showed 122×10^4 tons and 24×10^4 tons respectively. This results showed that protect adult stage stock better than protect larvae and juvenile stage stock for anchovy resource management.

**REFERENCES**


Optimal harvest strategies based on a stage-structured model for sandfish in the East Sea

Giphil Cho¹, Sukgeun Jung², Il Hyo Jung¹

¹Department of mathematics, Pusan National University, Busan
²Department of Marine Life Sciences, College of Ocean Sciences, Jeju National University, Jeju
giphil@pusan.ac.kr

We propose optimal harvest strategies using a stage-structured fishery model with impulsive system. The economical objective is to maximize the profit of fishing in fisheries management. Fishing effort used to harvest is used as a control to investigate the optimal utilization of the resource in economic sense. We analyze the economical optimal harvest strategy of sandfish caused by monthly price change. The optimal control problem is solved numerically using forward backward sweep method. Simulation results show the difference of the harvest strategies of the sandfish with and without considering monthly price. We expect that maximum sustainable yield of the sandfish can be increased by approximately 13.5% due to the optimal harvest strategies. The parameters of reproduction rate and growth equation of the sandfish in the model were derived from data of otolith and gonad analyses of female sandfish. And we estimated the age-specific natural mortality of the sandfish assuming natural mortality as an inverse function of total length.

REFERENCES

Session A2

빅데이터와 동물질병 관리

Organizer: 박홍식 (농림축산검역본부)

Date/Time: 6월 27일(화) 15:30

Speakers:

1. 정우석 (농림축산검역본부)
2. 윤하정 (농림축산검역본부)
3. 이원진 (농림축산검역본부)
mBird, Wild Bird Movement Visualization Web Site

Wooseog Jeong, Yong-Myung Kang, Hachung Yoon, Kihyun Cho, Hong-Sik Park.

Veterinary Epidemiology Division, Animal and Plant Quarantine Agency (APQA)

wjeong@korea.kr

A web-site(mbird.or.kr) examining real-time and archive positions of wild birds were constructed. This site was based on signals from geographical positioning system (GPS) devices attached through APQA’s program for preventing highly pathogenic avian influenza (HPAI). Signals of wild birds’ position is captured through GPS combined with wide band cede division multiple access (WCDMA) mobile phone network with global roaming. The website contains migratory routes (not only in Korea, but also China, and Mongolia) of wild birds with GPS by year, type, time and region.

REFERENCES

Understand Current Issues on the Foot-and-Mouth Diseases: Role of Mathematic Models

1Hachung Yoon, 1Wooseog Jeong, 1Ki-Hyun Cho, 1Yong-Myung Kang, 2Chang-Hyung Lee, 2Pil-Won Kim, 2Hyo-Jung Lee, and 1Hong-Sik Park.

1Veterinary Epidemiology Division, Animal and Plant Quarantine Agency (APQA)
2Department of Mathematical Science, Ulsan National Science and Technology Institute (UNIST)

heleney@Korea.kr

Since the big epidemic of foot-and-mouth disease (FMD) in the UK in 2001, mathematic models became an essential tool for epidemiological analysis of the outbreak. Many different models have been developed to describe and analyze transmission of FMD among susceptible cloven hoofed animals. A set of mathematical models was developed in cooperation with APQA and UNIST. The models consist with stochastic one for within-farm spread and the other for between-farm transmission, in aiming at improving understanding about FMD situation in the Republic of Korea. Specific features of these models include regular vaccination implemented on cattle, pigs, goats and deer in Korea, and following routine surveillance based on serological test. Answers to some current issues on FMD outbreak (i.e. infection dynamics both levels at animal and farm, sensitivity and specificity of serological test for detecting antibody, estimation of infection date, etc.) will be drown through these models.

REFERENCES
Big Data Machine Learning Risk Assessment on Highly Pathogenic Avian Influenza (HPAI) for Poultry Farms

Hachung Yoon, Wonjin Lee, Wooseog Jeong, Kihyun Cho, Yong-Myung Kang, Chung-Sik Jung, Hong-Sik Park

Veterinary Epidemiology Division, Animal and Plant Quarantine Agency (APQA)

heleney@Korea.kr

From November 2016 to April 2017, HPAI caused extensive damage to livestock farms in Korea. With collaboration with KT, APQA has developed big data machine learning risk assessment model based on neural network by livestock-related vehicles. Risk for HPAI outbreaks were served for 8,373 poultry farms (with duplicate). There was a certain contribution to preventing the spread of HPAI not only that the possibility of training with new data is sufficient for more sophisticated models.

REFERENCES

Session B1

심포지엄: 생태계 교란 평가를

위한 생태모델링

Organizer: 박영석 (경희대학교)

Date/Time: 6월 28일(수) 10:00

Speakers:

1. 배미정 (국립낙동강생물자원관)
2. 이대성 (경희대학교)
3. 홍철 (전남대학교)
4. 이다영 (경희대학교)
5. 문미영 (경희대학교)
Determining the environmental factors to pattern ETP endemic species in Korea

Mi-Jung Bae¹, Young-Seuk Park²

¹Freshwater Biodiversity Research Division, Nakdonggang National Institute of Biological Resources
²Department of Life and Nanopharmaceutical Sciences, and Department of Biology, Kyung Hee University

Endemic species which inhabit in a very limited area are very vulnerable with small changes of environmental factors. However, up to our knowledge, there has been no research on the diversity, distribution and conservation of endemic macroinvertebrates on the nationwide scale. Thus, we aimed to identify influential environmental factors on the EPT (Ephemeroptera, Plecoptera and Trichoptera) endemic species in streams. EPT Endemic species data were obtained from the database in the National Aquatic Ecological Monitoring Program from the Ministry of Environment and National Institute of Environmental Research, Korea. Cluster analysis (CA), non-metric multidimensional scaling (NMS) and random forest was conducted, in order to provide the information on the diversity and distribution of endemic EPT species. In CA, the study sites were divided into four clusters based on the similarities of EPT endemic species composition. In NMS, the first three axes (stress value=7.32) showed the highest relationship with annual average temperature following August temperature, January temperature, altitude, etc. In RF, the occurrence of each endemic species based on environmental factors was well predicted with high prediction power ranging 0.990 to 0.998. Geographical and meteorological factors were mainly selected as the influential factors on the species distribution.
기후변화에 따른 왕우렁이(Pomacea canaliculata)의 잠재적 서식지 예측

이대성, 박영석*

경희대학교 생물학과
dleotjd520@naver.com; parkys@khu.ac.kr

세계자연보전연맹(IUCN)에서 지정한 ‘세계 최악의 100 대 침입외래종’ 중 하나인 왕우렁이(Pomacea canaliculata)는 1983년 식용을 목적으로 국내에 첫 도입되었다. 하지만 도입후 왕우렁이를 이용한 잡초 제거 방법이 친환경 농법으로 각광받고 사용되면서 왕우렁이는 전국 각지의 농경지에서 흔히 볼 수 있게 되었다. 현재 환경부에서는 왕우렁이를 생태계의 요긴 2급으로 지정해 왕우렁이가 생태계에 미치는 영향에 대해 지속적으로 모니터링 해오고 있다. 본 연구는 왕우렁이의 현재 국내 분포 및 그 생태학적 특성을 파악하여 앞으로 기후변화에 따른 잠재적 서식지의 분포 변화를 알아보기 위해 진행되었다. 문헌 및 인터넷, 현장조사를 통해 과거부터 현재까지 한국 내 왕우렁이 관찰지 600여 곳의 생태학적 특징을 5종류의 범주로(수질, 수리수문, 서식지주변환경, 지리적 조건, 기후조건) 정리하여 DB화 하였다. 또한 기후변화 자료(IPCC 5차 보고서 RCP 8.5 시나리오)와 random forest 모델을 이용한 종분포모델링(SDM)을 통해 기후변화에 따라 변화되는 왕우렁이의 잠재적 분포 범위에 대해 분석하였다. 그 결과 현재 왕우렁이는 제주도 및 전남 해남에서부터 한반도 내륙, 강원도 철원에 이르기까지 전국 각지에서 분포하고 있으며, 기후 변화에 따라 왕우렁이의 서식가능 범위가 현재보다 고도가 높은 더 상류인 지점을 확대되는 양상을 보였다. 본 연구결과, 왕우렁이의 잠재적 서식지 분포가 전국적으로 확산될 것으로 예상됨에 따라 생태계 관리 차원에서 왕우렁이에 대한 지속적인 관심과 연구가 필요하다.
Changes of benthic macroinvertebrate community composition following summer precipitation using self-organizing map

Cheol Hong and Ihn-Sil Kwak*

Department of Fisheries and Ocean Science, Chonnam National University

To investigate the changes of macroinvertebrate community composition according to summer precipitation, we surveyed 20 main streams of Seomjin River in May and September, 2016. The precipitation which is main factor for changing community compositions in stream ecosystems, dominant species of benthic macroinvertebrates, community indices, EPT were collected and measured. The cumulative precipitation (CP) of Seomjin River increased more than 2000mm from May to September, and more than 400mm in every regions respectively. Total number of individuals (16162→7637 ind.m$^{-2}$) and species (84→71) for benthic macroinvertebrates were decreased in September. Richness index (2.71→2.52) was decrease in September. The dominant species Chironomidae sp. (3085.8 ind.m$^{-2}$, 38.3%) was high in May, and Ecdyonurus levis (910.2 ind.m$^{-2}$, 26.3%) was high in September. EPT ratio was higher in May than September because of increasing of the ephemeroptera. According to result of self-organizing map based on CP and dominant species in Seomjin River, it was divided into two groups following CP through ordination and clustering, and the geographical position was reflected and divided into detailed groups.
환경교란이 하천의 잠자리목 군집 변화에 미치는 영향 예측

이다영, 이대성, 박영석*

경희대학교 생물학과
darami@khu.ac.kr; parkys@khu.ac.kr

잠자리목은 한국에서 흔히 관찰되는 분류군이다. 세계적으로 6,000종 이상이 분포하며 한국에는 11과 125종이 보고되었다. 종다양성과 종수도에도 불구하고 우리나라 하천에 서식하는 잠자리목의 전국적인 분포 현황에 대한 연구는 제한적인 실정이다. 이 연구에서는 우리나라 하천에 서식하는 잠자리목 유충의 분포와 서식환경의 특성간의 관계를 연구하고, 이를 바탕으로 기후변화에 따른 잠자리목의 분포를 예측하고자 한다. 기존에 총괄된 데이터베이스 검색을 통해 잠자리목 분포 현황을 다룬 자료를 만들었고 문헌조사를 통해 생물학적 특징과 서식지 특성을 다룬 자료를 구축하였다. 잠자리목의 전국적인 분포 조사는 전국 1159개 지점에서 93종을 대상으로 이루어졌으며, 이 중 965개 지점에서 10과 79종의 잠자리목이 관찰되었다. 환경변수는 크게 지리적 변수, 수리수문학적 변수, 하상구조, 서식지 수질특성, 수질 부분으로 나누어 분석을 진행하였다. 잠자리목의 분포 특성에 따라 각 지점을 Self-Organizing Map(SOM)을 통해 7개의 그룹으로 나누었다. 각 그룹은 서식지의 환경 특성을 반영해주었다. 이후 RCP8.5 시나리오를 적용한 Random Forest 모델을 통해 잠자리목의 분포를 확인 및 예측하였다. 그룹의 우점은 방울실잠자리, 쇠측범잠자리, 어리장수잠자리, 아시아실잠자리, 물잠자리, 노란총범잠자리로 나타났다. 각 그룹의 지표종은 그룹 2에서 쇠측범잠자리, 그룹 4에서 애기총잠자리, 그룹 5에서 검은물잠자리, 그룹 6에서 동근은실잠자리, 그룹 7에서 노란총범잠자리로 나타났다. 환경변수에서는 고도와 수변서식지 특성이 잠자리목의 분포에 주된 영향을 미치는 것으로 밝혀졌다. 기후변화에 따른 잠자리목의 다양성은 2060년대까지 점차 증가하는 경향성은 보이나 이후로는 감소할 것으로 예측되었다.
하천에 서식하는딱정벌레목의다양성에미치는환경인자

특성 분석

문미영1, 이대성1, 천정화2, 박영석1*

1경희대학교 생물학과, 1국립산림과학원 산림생태연구과
mrm5461@naver.com; parkys@khu.ac.kr

저서성딱정벌레목은우리나라에약146종이넓게서식하는 것으로보고되었다.수생태계에서딱정벌레목은생물지표종으로많이이용되지만전국적인분포수준에서의환경교란이미치는영향에대한자료는부족한실태이다.따라서본연구는하천에서식하는딱정벌레목의분포유형과기후변화등을포함하는다양한환경인자에따른생물군집의변화를평가분석하였다.자료는DB검색을통하여딱정벌레가서식하는958지점에66종이포함된DB를만들었다.또한각조사지점에서조사된환경인자를물리화학적수질인자,기상인자,서식지인자등세가지카테고리에서10개의환경인자를DB로부터축출하여사용하였다.

비지도학습인공신경회로망인Self-OrganizingMaps(SOM)을이용하여딱정벌레군집을군집구성의유사성에따라유형화하였다.그결과,군집은9개그룹으로나뉘어졌다.그중7개군집은우점종이많이분포하였으며,나머지2개군집은출현종의빈도및개체수가적었다.각군집은환경변수별로서로다른특성을나타내었는데고도,수질인자,탁도가한계영향을주었으며특히고도가가장많은가이를하였다.한편RCPS.5시나리오를바탕으로기후변화가우리나라수생태계종분포미치는영향을선형회귀분석을이용한다중모델추론(MuMin)방법으로예측하였다.그결과,기후변화에따라전체적인종다양성은감소하였다.특히Peltodytesintermedius같은추위에적응된종은기후변화에더욱예민하게반응하여분포가감소하였으며,Hydrophilidaesp.같이더위에적응된종은조금은증가하는분포양상을보였다.
Session B2

Stochastic Fluctuations in Biological Circuits

Organizer: 김철민 (UNIST)

Date/Time: 6월 28일(수) 10:00

Speakers:

1. 성재영 (중앙대학교)
2. 송태근 (아시아태평양 이론물리센터)
3. 조정효 (아시아태평양 이론물리센터)
Chemical fluctuation theorem
for vibrant enzyme networks in living cells

Jaeyoung Sung

Creative Research Initiative Center for Chemical Dynamics in Living Cells, National Institute of Innovative Functional Imaging, and Department of Chemistry, Chung-Ang University, Seoul 06974, Korea.

An intracellular reaction network is often constituted by complex stochastic processes interacting with cell environments. To understand how accurately living cells can control their biological functions, it is essential to construct a rigorous mathematical description for chemical dynamics of intracellular networks interacting with complex and hidden cell environment. In this presentation we introduce a novel model and stochastic kinetics for intracellular networks interacting with cell environment, employing a complete description of cell state dynamics and its coupling to the system network. For a general model of intracellular birth-death processes, we present the chemical fluctuation theorem (CFT) that relates microscopic dynamics of the birth and death processes to the cell-to-cell variation in the product number. Combined with a new mathematical description of the gene expression network coupled to cell environmental variables and to a control variable, CFT provides an excellent quantitative explanation of the cell-to-cell variation in the mRNA and protein levels for various recently investigated systems in a unified manner. Our analysis of mRNA counting statistics in Escherichia coli shows that the transcription of an active gene is a strongly non-Poisson process whose rate coefficient is a dynamic stochastic variable with either oscillatory or monotonically decaying time correlation function (TCF). The shape of the TCF of the rate coefficient has an important consequence for the cellular control over the transcriptional noise. This work demonstrates a promising, new approach in quantitative biology, attempting to make complex dynamics of chemical reactions in living cells and its biological consequence accessible to a rigorous mathematical description. Time permitted, I will also discuss non-classical stochastic kinetics of clonal yet heterogeneous single enzymes.
An Artificial Hair cell Modeling:
Characteristics and mechanisms of a hair cell

Taegeun Song

JRG of Designing Principles of Cellular Networks
Asia Pacific Center for Theoretical Physics
taegeun.song@apctp.org

I introduce an artificial hair cell model inspired by the gating-spring model of the hair cell in the mammalian auditory organs [1,2]. The organ shows astonishing performances: coping with a huge range of sound pressure levels, distinguishing two different frequencies less the 1 Hz within one second, and detecting weak sound signal comparable to thermal fluctuations. Those remarkable properties originate from active components of hair cells in the cochlea. The hair cell shows two crucial physiological properties: mechanical instability and sensory adaptation. A mathematical model for describing hair cells is the gating-spring model in which mechanoelectrical transduction generated by mechanical signals is transmitted through a gating spring to the myosin molecular motor of each transduction channel, and then it increases tension in the gating spring and promotes the channel's transition from closed to open states [1]. We proposed a biomimetic electromechanical system, mimicking biological hair cells and their physiological properties, using feedback control [2]. We successfully realized our model in an optoelectromechanical system, and we used it to indirectly investigate the physical limits of the hair cell sensitivity, frequency selectivity, and signal-to-noise ratio. Furthermore, we tested noise effect on the Hopf bifurcation hypothesis that is experimentally inevitable and so attracts large attention, and suggested that many puzzling aspects of hearing could be explained by a generic model [3,4].

REFERENCES

Mathematical Modeling of Glucose Homeostasis

Junghyo Jo

Asia Pacific Center for Theoretical Physics
jojunghyo@apctp.org

Glucose is the primary energy source for life. Thus glucose homeostasis, maintaining the energy stable, is important, and its malfunction leads to the metabolic disease, diabetes. The islets of Langerhans in the pancreas regulate glucose levels through the counter-regulatory hormones, glucagon and insulin. The micro-organ has a unique spatial organization of alpha, beta, and delta cells [1]. Furthermore, the islet cells secrete glucagon, insulin, and somatostatin in a pulsatile manner. Since they can spontaneously generate the hormone oscillations even in the absence of coupling between them, and they interact to each other with special symmetries, we can model their hormone dynamics as coupled oscillators. We investigate (i) how their spatial organization and interaction coordinate the hormone secretion in the intra-islet network [2], and (ii) how the local interaction between alpha, beta, and delta cells coordinate the global synchronization of the inter-islet network [3]. The structure-dynamics-function modeling of islets concludes that the design of the hierarchical islet network can provide controllable synchronization. Synchronous hormone secretion under high/low glucose conditions can amplify its action, while asynchronous hormone secretion under normal glucose conditions can suppress its unnecessary action.

REFERENCES

Session B3

Infectious Disease

Modeling and Diffusion

Organizer: 이창형 (UNIST)

Date/Time: 6월 28일(수) 10:00

Speakers:

1. 이선미 (경희대학교)
2. 이효정 (Hokkaido University)
3. 이종걸 (건국대학교)
4. 고원률 (고려대학교)
Modeling human mobility in two-patch epidemic models

Sunmi Lee

Department of Applied Mathematics
Kyung Hee University
sunmilee@khu.ac.kr

In this talk, we review two-patch epidemic models to explore the impact of human mobility on the disease transmission dynamics. Some exiting epidemic models are revisited, where the movement of individuals between and within patches is modeled by a residence-time matrix. This framework incorporates human mobility in which the risk of infection is a function of the residence-time and local environmental risk. This approach generalizes the traditional multi-patch epidemic models with heterogeneous mixing. We employ this approach to a general two-patch dengue model in order to investigate the effects of human mobility patterns on the dengue transmission dynamics.

REFERENCES

Modeling the Impact of Climate Change on Dengue Fever Incidence in Korea

Hyojung Lee, Jung Eun Kim, Sunmi Lee and Chang Hyeong Lee

Department of Hygiene, Graduate School of Medicine, Hokkaido University, Sapporo, Japan
hjleebiomath@gmail.com

Dengue fever, which is transmitted by Aedes mosquitoes, is the most dominant vector-borne viral disease in the world. Although the autochthonous cases of dengue fever have not been reported yet in Korea, the dengue incidence has been increasingly imported by travelers returned from endemic area. On the other hand, climate changes are strongly associated with the spread of infectious mosquitoes. Therefore, increased international travelers and the climate changes increase the risk of dengue transmission in Korea. Since the secondary infection with the other dengue virus from primary infection is known as a risk factor of developing the severe disease, we develop a two-strain dengue model for primary and secondary infection based on [1]. Entomological parameters for mosquito’s life cycle are represented by temperature-dependent functions [2]. According to four scenarios of Representative Concentration Pathways (RCPs) as future climate data [3], we investigate the impact of climate changes on cumulative incidence. Furthermore, we explore the effect of control for importing cases from international travel.

REFERENCES

The role of spatial transmission and control measures in the avian influenza epidemic 2016-2017 in Korea

Jonggul Lee, Youngsuk Ko, Junho Lee, and Eunok Jung

Department of Mathematics
Konkuk University
Jg4lee@gmail.com

Highly pathogenic avian influenza (HPAI) A virus (subtype H5N6 and H5N8) has caused a recent outbreak in Korea since November 16, 2016. Over 37 million poultries in 946 farms including 383 infected farms had been culled up to date. Here we construct a mathematical model for the HPAI outbreak in two provinces in Chungcheongbuk-do based on the assumption of spatial and host heterogeneities of poultry farms. Culling of infected farms and pre-emptive culling of farms in high-risk premises are incorporated into the model by using the geographic data, such as farm density. We observed significant differences of transmission rates between chicken and duck farms. The effective infectious radius (with lower values indicating higher spatial heterogeneity) was approximately 1.5 km which is greater than the radius of infected premises, 0.5 km. Finally, we also present results of case studies focused on the role of preemptive culling.

REFERENCES
On the Dynamics of Predator-prey Systems with a Functional Response Describing Predator Grouping

Wonlyul Ko

Department of Mathematics
Korea University
kowl@korea.ac.kr

The current paper describes the qualitative study of a predator-prey system with a functional response describing behavioral mechanism of certain predator's spatial foraging in linear schools versus school. In the system, the existence of all feasible nonnegative equilibria is determined, and further the stabilities and types of the equilibria are investigated. Based on this, it is shown that the various bifurcations such as the saddle-node, Hopf and Bogdanov-Takens can take place at some positive equilibria. Numerical simulations are given to support our results. Finally, to study the spatial dispersal of the species in the system, diffusion terms are introduced, and then in the obtained reaction-diffusion system, numerical simulations to illustrate the emergence of spatiotemporal patterns, is also performed.
Session C1

기후변화 영향평가를 위한 RCP 기반

기후변화 응용정보 생산

Organizer: 정일효 (부산대학교)

Date/Time: 6월 28일(금) 15:30

Speakers:

1. 김성찬 (부산대학교)
2. 이슬기 (고려대학교)
3. 이주현 (전남대학교)
4. 박재록 (부산대학교)
기후변화 영향평가를 위한 RCP 시나리오 기반

행정구역별 기후자료 산출

조기필¹, 김성찬¹#, 정용담¹, 정일효¹##

¹Department of Mathematics, Pusan National University, Busan 46241, Korea
## ilhjung@pusan.ac.kr

IPCC 5차 평가보고서에는 대표농도경로 RCP(Representative Concentration Pathways)를 새로운 시나리오로 사용하며, RCP 시나리오는 최근 온실가스의 농도 변화를 반영하여 최근 예측 모델에 맞게 해상도 등도 업데이트 하였다. RCP 시나리오란 온실가스 농도값을 설정 후 기후변화 시나리오를 산출하여 그 결과의 대책으로 사회, 경제 분야별 온실가스 배출 저감 정책을 결정하는 시나리오 중 하나이다. 이 RCP 데이터는 남한 1km, 한반도 12.5km 격자 단위로 생성되어 있는데, 연마 다 실시되는 기후변화 영향평가를 위해서는 행정 구역별 기후 자료를 산출하는 것이 필요하다. 따라서 본 연구에서는 격자 단위의 RCP기반 기후 자료를 행정구 역별로 산출하는 방법과 이를 통해 생성된 기후 자료를 소개한다.
RCP 시나리오에 따른 미래 AII (Simple Aridity Intensity Index) 변화와 식물분포에 미치는 영향

Sle-gee Lee, Chul-Hee Lim, Cholho Song, Seongbong Heo, Woo-Kyun Lee
cristallize@naver.com

기후변화는 크게 온도와 강수량의 변화로 나타나며, 이는 산림 식생대, 수종변화, 생장패턴, 생산성 등에 영향을 주는 것으로 알려져 있다. 최근의 극심한 기후변화 추세로 인하여 산림분야의 기후변화 영향을 예측하고 관리하기 위한 기후변화 대응 계획을 시급히 마련할 필요가 있다. 이러한 취지에서 정부 각 부처 산하 기관에서 산림분야의 기후변화 영향 및 취약성 평가와 적응대책 수립을 위한 다양한 연구들이 진행되어 왔으나, 체계적인 자료의 관리, 적용, 응용을 위한 구체적인 기술 개발은 미흡한 관이다. 특히, 기후변화에 따른 산림생장, 분포, 탄소 변화 등의 예측에 직접적으로 활용할 수 있는 응용 기후변화 정보 데이터는 극히 부족한 상황이다. 본 연구에서는 RCP 시나리오를 토대로 기후변화 응용 정보를 생산하여 기후변화에 대한 산림 변화를 예측하고 관리 정책을 수립하기 위한 기초 자료를 제공하는 것을 목적으로 한다. 구체적인 응용 정보는 산림분야에서 활용성이 높은 지수인 MTCI(Minimum Temperature Index of the Coldest Month), PEI(Precipitation Effectiveness Index), AII(Simple Aridity Intensity Index)를 대상으로 한다.

식생의 내한성을 표현하는 MTCI와 산림과 분포를 표현하는 PEI의 경우 기상청에서 일부 시나리오를 대상으로 국내 자료 생산이 진행중이다. AII는 건조한 상태의 규모를 보여주는 지수로 건조한 날의 총강수량과 건조한 날의 수의 비로 표현되는데, 최근 대두되고 있는 가뭄에 대한 영향을 정량화할 수 있는 지수에 해당한다. AII는 토지의 취약성 또는 산사태 위험성 등의 연구에 활용된 사례가 있고, 산림 분야의 경우 한반도 산림의 건조 상태에 대한 미래 예측값을 제시할 수 있다는 점에서 활용도가 높다.

\[
AII_j = \frac{\sum_{D=1}^{D} RR_{D_j}}{D} 
\]

\(RR_{D_j}\): the daily precipitation amount on dry days
\(D\): the number of dry days in \(j\)

AII는 RCP 4.5와 8.5 시나리오를 대상으로 2011년부터 2100년까지의 시간적 범위에서 생산이 되었고, 기간별 변화 패턴을 확인하기 위하여 30년 평균 AII 형태로 표현하여 산림의 변화를 반영할 수 있도록 범위를 설정했다. 미래 단기(2011-2040년), 중기(2041-2070), 장기(2071-2100) 결과를 기준으로 AII는 강수량과 건조일수의 비로 표현되는 특성에 따라 시기별 변화 패턴이 크게 달라질 것으로 분석되었다. 이는 PEI와 유사한 형태를 보이고 있는 데, 이러한 간수 관련 지수는 기온에 비해 공간상관성이 낮게 나타나는 일반적인 사실과 관련이 있는 것으로 분석되었다. RCP 4.5와 8.5 시나리오를 비교하였을 때 AII 값의 분포 패턴이 다소 차이가 있는 것으로 나타났고, 전반적으로 RCP 8.5 시나리오의 시계열 변화가 두드러진 결과가 도출되었다.

REFERENCES
기후변화 영향평가를 위한 RCP 시나리오 기반

Oi (Ombrothermic Index) 생산 및 양서파충류 변화상 예측

이주현1, 강희진2, 윤지영2, 성하철*

1Department of Biology in Chonnam National University
2School of Biological sciences and Biotechnology in Chonnam National University
* shcol2002@jnu.ac.kr

온실가스 증가에 따른 지구온난화는 전지구적 기후변화를 불러일으켰다. 특히 동물상의 경우, 선진국에서는 이미 생물 다양성 보전과 멸종위기종 보호를 위해 다양한 응용정보 생산과 동시에 미래 예측 시나리오를 적용하였다. 이에 따라 국내외에서 기후변화 시나리오를 활용한 동물생태분야 응용지수 산출에 대한 관심이 점점 높아지고 있다. 특히 양서류와 파충류는 그들의 생존에 기온변화와 강수량의 변화가 밀접하게 연관되어 있기 때문에 기후변화에 대표적인 동물상으로 분류된다. 본 연구에서는 기후변화 시나리오 중 RCP (Representative Concentration Pathways) 기후변화 시나리오에 의거, 기후변화에 따른 응용정보지수를 산출하였다.

이에 따라 본 연구에서는 RCP 4.5, 8.5 시나리오를 활용하여 Oi (강우열량지수; Ombrothermic index)를 산출, 기후변화에 따른 양서파충류 서식지의 기후공간 변화 및 생존환경을 예측하고자 하였다. Oi는 강수량과 기온의 혼합지수로서 평균기온이 0°C 이상인 개월의 강수량과 평균기온의 총합을 나타낸다. 이를 통해 생물의 생존환경 및 종영토도와 연관된 기후대를 정의할 수 있다. RCP 시나리오 상 Oi 지수는 공동적으로 내륙산간지역에서 변화상이 높게 나타났다. 또한 RCP 4.5 시나리오 보다 RCP 8.5 시나리오에서 지수의 변동폭이 높게 나타나 생물종에 영향을 미치는 기후변화 심각도가 더욱 크게 나타났다. 따라서 Oi 지수를 통해 생물종 및 서식지 취약성이 높은 지역의 보호대책 우선수립이 요구되며 위 지수의 영향을 가장 많이 받는 양서파충류에 대한 지속적인 연구 및 보호관리가 필요하다.
Analysis the dispersion of raining day-rainfall with RCP scenario in Korea

Jaerock Park, Junghye Min, Byungsung Kim and Hyunsuk Shin

Department of Civil Engineering, School of urban, Architecture and Civil Engineering
Pusan National University
Closej524@gmail.com

REFERENCES

Session C2

General Session

Organizer: 이완호 (NIMS)

Date/Time: 6월 28일(토) 15:30

Speakers:

1. 진홍성 (전남대학교)
2. 이완호 (NIMS)
3. 이승규 (NIMS)
4. 변종혁 (부산대학교)
GMO 유전자를 갖는 옥수수의 천이 분석

김아진¹, 곽준우¹, 한동엽², 진홍성³,*

¹전남대학교 치과전문대학원, ²전남대학교 해양토목공학과, ³전남대학교 수학과

hjin@chonnam.ac.kr

GMO 유전자를 갖는 작물은 제초제나 해충에 잘 견디는 방향으로 출발하여 작물의 생산량을 높이는 방향으로 수십 년째 연구와 생산이 진행되고 있다. GMO 작물은 대량생산을 통한 공급의 안정성을 확보한다는 점에서는 매우 큰 장점을 갖고 있으나 최근 생물 다양성의 훼손이나 예기치 못한 여러 내성을 갖는 해충의 등장으로 GMO 작물의 재배에 심각한 우려가 제기되고 있다. GMO작물은 일반 야생작물에 비해 우성의 유전자를 갖고 있으며 의도하지 않은 접촉으로 유기농 작물이 GMO유전자에 의해 오염되는 사례도 빈번하게 발생하고 있다.

본 연구에서는 GMO 유전자 중에서 옥수수 유전자의 천이 현상을 여러 경우로 나누어 시뮬레이션 해 보았다. 셀룰라 오토마타 방법을 활용하였고 Toom’s Rule을 변형시켜 적용하였다.
A microscale model of bacterial flagella motility

Wanho Lee¹, Yongsam Kim², Boyce E. Griffith³, and Sookkyung Lim⁴

1) Division of Strategic Research, National Institute for Mathematical Sciences, Daejeon 34047, KOREA
2) Department of Mathematics, Chung-Ang University, Seoul 156-756, KOREA
3) Department of Mathematics and McAllister Heart Institute, University of North Carolina, North Carolina, USA
4) Department of Mathematical Sciences, University of Cincinnati, 4199 French Hall West, Cincinnati, Ohio 45221, USA
wlee@nims.re.kr

The helical flagella that are attached to the cell body of bacteria such as Escherichia coli and Salmonella typhimurium allow the cell to swim in a fluid environment. In this talk we will present a mathematical model of one or several rotating flagella described by Kirchhoff rod theory that is immersed in a fluid governed by Stokes equations. We show simulation results of a motor-driven flagellum where a filament is undergoing a polymorphic transformation from the left-handed helix to the right-handed helix as the motor reverses from CCW to CW. We also show the bundling phenomenon that occurs when several flagella rotate. These studies can help understand the swimming movement of E. coli and understand the efficient movement in a microscale environment.

REFERENCES

Mathematical model for contractile ring-driven cytokinesis using IB and PF methods

Seunggyu Lee
Division of Strategic Research
National Institute for Mathematical Sciences
sglee89@nims.re.kr

In this talk, a mathematical model of contractile ring-driven cytokinesis is presented by using both phase-field and immersed-boundary methods in a three-dimensional domain. It is one of the powerful hypotheses that cytokinesis happens driven by the contractile ring; however, there are only few mathematical model following the hypothesis in author’s knowledge. I consider a hybrid method to model the phenomenon. First, a cell membrane is represented by a zero-contour of a phase-field implicitly because of its topological change. Otherwise, immersed-boundary particles represent a contractile ring explicitly based on the author's previous work. Here, the multi-component (or vector-valued) phase-field equation is considered to avoid the emerging of each cell membranes right after their divisions. Using a convex splitting scheme, the governing equation of the phase-field method has unique solvability. The numerical convergence of contractile ring to cell membrane is proved. Several numerical simulation are performed to validate the proposed model.

REFERENCES
The change of TGI and total payloads in tumor cells according to linker stability: What are the better strategies either the linker or the payload improvement?

Jong Hyuk Byun, Il Hyo Jung

Department of Mathematics, Pusan National University, Busan 46241, South Korea

maticax@gmail.com

Antibody drug conjugates, ADCs, are potent anti-tumor chemotherapeutics that work only the specific target to want to treat. It consists of monoclonal antibodies, linkers, and potent cytotoxic drugs. Unlike common chemotherapies, ADCs combine selectively with the target at tumor cell surface and potent cytotoxic drug (payload) effectively prevents microtubule polymerization. This magical drug has theoretically perfect but linkers are not stable and payloads release in the circulation before binding the target, and payloads are diffused to intracellular and extracellular by pH difference. It may cause side-effect in the body. In this work, we construct an ADC model that considers both the target of antibodies and the receptor (tubulin) of the cytotoxic payloads, presents the comparison with tumor size prohibition effects according to linker stabilities and theoretical inhibition to diffuse. This research will propose a strategy to choose better one, the linker or the payload improvement.

REFERENCES


Tutorial Session
I. Mathematical Modeling of Biological Systems

Jung Eun Kim

UNIST
jkimmath1@unist.ac.kr

Mathematical models are increasingly used to understand the mechanisms in biological systems. In this talk, modeling biological problems will be discussed, especially by using systems of ordinary differential equations (ODEs). Several mathematical models for basic qualitative behavior in biological systems will be introduced such as chemical reactions inside a cell, simple population dynamics, and action potentials in neurons.
II. Stochastic Modeling in Epidemiology

Jung Eun Kim

UNIST
jkimmath1@unist.ac.kr

In order to understand biological systems, deterministic models are widely used, but they could not explain some dynamics of the systems, for instance, the qualitative behavior of infectious disease outbreaks such as the time distribution to extinct or the distribution of final epidemic size. Stochastic models can be a good alternative to study dynamics of the system which can not be investigated by deterministic models. A brief introduction to the various types of stochastic epidemic models will be presented based on the well-known deterministic SIR epidemic model. Three different approaches will be introduced to analyze the stochastic models: continuous time Markov chain model, stochastic differential equations, and the moment closure method. We will discuss properties of these models and numerical simulation methods for them (eg. Gillespie SSA algorithm, Euler-Maruyama method). More complicated applications will also be shown. (eg. vector-borne disease model)
Poster Session
A MATHEMATICAL MODEL OF MONKEY’S CIRCADIAN RHYTHM FOR DEVELOPING A NEW DRUG

Kim DaeWook
Department of Mathematical Sciences, KAIST
0308kdo@kaist.ac.kr

Mammalian Circadian rhythms synchronize various external environments to keep ~24h period. One of the main factors that affect Circadian rhythms is light. Also, circadian rhythms can be controlled pharmacologically, for instance, using the Ck1δ/ε inhibitor, PF-670462. Surprisingly, PF-670462 has different pharmacokinetics (PK) behaviors between monkey and mouse. For example, the dosing exposure of monkey is higher than mouse. To reflect and research the difference, we develop the non-human-primate (NHP) pharmaco systems model as modifying the original mouse suprachiasmatic nuclei (SCN) pharmaco systems model. By using the new NHP model and experimental data, we predict and validate that the dosing effect is very different depending on dosing time. We also find the monkey's counteracting effect of light on dosing is stronger than a mouse. This work indicates that even, in the case of NHP, dosing timing and environmental factors should be carefully considered to get the desired manipulation of circadian phase.

REFERENCES

Comparison of Two Types of Gene Repression in a Circadian Clock

Euimin Jeong

Department of Mathematical Sciences, KAIST
Wjddmlals11@kaist.ac.kr

Every organisms have a circadian clock controlling daily cycle of lives. For example, human body shows the sharpest blood pressure rise about 6:45 a.m., or secretes melatonin about 9:00 p.m. to induce sleep. This 24 hour rhythms are regulated by a transcription-translation feedback loop(TTFL) with the CLK-BMAL1 activator complex and PER, CRY proteins. When activator CLK-BMAL1 bind E-box, E-box transcribes mRNA, which is translated to PER and CRY repressors. After translation, PER and CRY repress E-box in two ways. First, CRY proteins repress transcription by binding to CLK-BMAL1-Ebox complex and stay there. Hence, it is called 'blocking-type repression'. However, if PER-CRY complex binds to CLK-BMAL1-Ebox complex, then it takes off CLK-BMAL1 complex from E-box. So, it is called by 'displacement type repression'. To describe these repression mechanisms, we use 8-dimensional ordinary differential equation(ODE) model involving the binding reaction between repressor and activated E-box. By the quasi-steady-state approximation(QSSA), model is reduced to 3-dimensional system, and we induce transcription function regulating a transcription of E-box. From this model, we compare two types of repressions, and furthermore we predict the role of PER and CRY proteins regulating repressions.

REFERENCES

Control strategies for rumor spreading depending on interest level of rumor

Yong Dam Jeong, Kwang Su Kim and Il Hyo Jung

Department of Mathematical Sciences, Pusan National University,
wde0539@hanmail.net

These days a variety of information diffuses quickly due to the development of various media such as social networks which can cause too many spreads of rumor. In this regard, we need strategies for controlling the rumor. This paper discusses optimal control for rumor spreading by using three strategies: 1) prevention of rumor 2) punishment for spreader 3) deleting information about the rumor in a medium. We show the existence of a control problem and solve optimal control problem by using forward-backward sweep method. Furthermore, since amounts of control are limited in the real world, we consider optimal control problem under isometric constraint. Finally, by using numerical simulation, we investigate optimal timing and amounts about three strategies for control of rumor spreading.

REFERENCES

A theoretical study on mathematical modelling of MERS-Cov transmission with application of optimal control

Dongho Lee*, Yongkuk Kim

Department of Mathematics, Kyungpook National University
^*. Presenter. ldh-0625@hanmail.net

In this talk, we propose and analyze a MERS-Cov epidemic problem. Using a SIR model, the basic reproduction number is obtained. Moreover, we consider two time-dependent control measures and obtain the optimal control strategy to minimize both the infected populations and the associated costs. All the analytical results are verified by simulation works.
A spatial SIS epidemic model with risk-induced dispersal

Wonhyung Choi and Inkyung Ahn

Department of Mathematics, Korea, University

whchoi@korea.ac.kr

ahnik@korea.ac.kr

A spatial SIS epidemic model is examined where dispersal of infected individuals is not linear. Spatial heterogeneity and disperse of individual are influential factors for the persistence and extinction of an infectious disease. It is well known that if the mobility of the infected individuals is above a certain value, then the disease may extinct in spatial SIS reaction-diffusion model. An area is called high (low) risk if the average of infection rates is bigger (less) than the average of the recovery rates. We will introduce a risk-induced dispersal (RID) for infected individuals: namely, the mobility of infected individual is high where they are in high risk area, and the mobility is low in low risk area. In this study, we examine the effect of RID for spatial SIS model. First, we define the basic reproduction number $R_0$ for spatial SIS reaction-diffusion model, and investigate the stability: if $R_0 < 1$, then disease-free state is stable, and if $R_0 > 1$, there is an endemic state. Furthermore, it is shown that risk-induced dispersal of infected individuals represents a better strategy to obtain the disease-free state than random dispersal strategy. This can be done by comparing the basic reproduction number $R_0$ of those models.

REFERENCES

Epidemic Model of Foot-and-Mouth Disease with Vaccine

Yongin Choi, James Slghee Kim, Chang Hyeong Lee

Department of Mathematical Sciences, School of Natural Sciences, UNIST,
Ulsan Metropolitan City 689-789, KOREA
yongin9@unist.ac.kr

Foot-and-Mouth Disease (FMD), an extremely infectious viral disease affecting cloven-hooved animals, has been a problem in South Korea in the past few decades causing severe financial damages nationwide in the livestock industry. Despite that culling is the main prevention measure of the spreading of FMD, alternative measures like vaccination has been implemented; however, the efficacy and influence of this measure still remains to be examined.

We establish a mathematical model which is an extension of the SIR model to examine the dynamics of FMD outbreak. An external source of infection is considered in the transmission process [1] to contemplate the repeated outbreaks in South Korea. In this work, we would like to explore the effects of different vaccination scenarios on the epidemics of FMD through simulations.

REFERENCES

Does movement toward better environment always benefit biological species?

Kwangjoong Kim, Wonhyung Choi and Inkyung Ahn
College of General Education, Kookmin University
kimkj82@kookmin.ac.kr

Department of Mathematic, Korea University
whchoi@korea.ac.kr, ahnik@korea.ac.kr

We study the effect of advection along environmental gradients on diffusive competition interacting systems of Lotka-Volterra type in heterogeneous environment. It is assumed that while the two species are ecological equivalent, they adopt different dispersal strategies: one disperses randomly and the other adopts, in addition to diffusion, a directed movement toward along the environment gradient. It is known that the one species with advection benefits the survival against the other competing species when the boundary of habitat is assumed as a reflecting barrier to the population, namely, sufficiently rapid movement in the direction is always beneficial [1]. In this study, the lethal environment is assumed on the boundary of habitat. We show that on the lethal boundary condition, movement up the gradient of resource may be either beneficial or harmful depending on the property of resource function. Competitive exclusion and coexistence can be happened depending on the situation of environment gradient and strength of advection. Simulations are presented based on our results in the 1-dimension case.

REFERENCES
