Towards Establishment of the Post-MAHASRI Science plan

Toru Terao (Kagawa Univ.), Shinjiro Kanae (Tokyo Inst. Tech.), Jun Matsumoto (TMU & JAMSTEC)
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
RHP’s in Monsoon Asia

- Monsoon Asia Hydroclimatological Research have continued since 1995 under GAME and MAHASRI
GAME/MAHASRI

- RHP of Asian Monsoon hydroclimate research
    - Atmosphere-land surface interactions
    - Four regional components => Cross cutting (2002-2004)
      - GAME-Siberia, GAME/HUBEX, GAME-Tibet, GAME-Tropics
    - Hydro-meteorological prediction system, up to a season
    - Based on collaboration of several regional projects
      - Maritime Continent, Thailand, Mongolia, Vietnam, South Asia …
    - Major Funding Source: JEPP -> SATREPS
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
Outcomes / Impacts of MAHASRI

1. Since the GAME period, Asian operational agencies and research communities strongly stimulate research activities in monsoon Asia.
   - Local agencies and research inst. development in Asian countries
   - Education / capacity building / PhD / Co-authored papers
2. A real-time monitoring and flood prediction system have been developed in the Chao Phraya River Basin in Thailand.
3. Dynamics of autumn/winter extreme rainfalls in Indochina have been extensively investigated.
   - In-situ observation datasets (DIAS) in the Univ.Tokyo
   - AMY Re-analysis by MRI (Meteorological Research Institute)
Potential Future Research Targets:

- Multi-scale interactions: diurnal/synoptic/ISO/seasonal changes in time, or local/regional/global changes in space
- Land–ocean–atmosphere interactions
- Changes and attribution of extremes
- Decadal variations of the Asian monsoon
- Effects of humans on the hydrological cycle
- Developing an adaptation strategy for climate changes
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
RHP Status

RHP: Regional Hydroclimatological Project

Active in 4 continents:
- Europe: **HymEx** (2010-2020) => High-impact weather events, societal response
- **Baltic Earth** (2016-) => Sea and land changes, biogeochemical processes
- Australia: **OzyWex** (2015-) => Water and energy cycle in Australia
- Africa: **HyVic** (2015-2024) => Hydroclimatic variability over Lake Victoria basin

Recently finished:
- Asia: **MAHASRI** (2007-2016) => Asian Monsoon

Prospective:
- Europe: **PannEx** (end 2017?) => Agronomy, air quality, sustainability & water mgnt

In discussion:
- Exploring possibilities in the Americas and Asia.

(Courtesy of Prof. Jason Evans, Co-chair of GHP)
Post MAHASRI Planning Activities

- 17-19 Oct. 2017: GHP/TPE-WS (Kathmandu)
- 2 Nov. 2017: Meeting in Sapporo
  - Discussion of the collaboration with TPE for meso-scale modeling
- 20 Jan. 2018: PostMAHASRI Planning Workshop
  - Nagoya University, Japan
  - More than 40 researchers
  - TMU (Tokyo Metropolitan University), Japan
  - 12 Asian researchers from 8 countries, Thailand, Vietnam, Philippine, Indonesia, China, Nepal, India, Bangladesh
  - Total 63 international researchers
Time Table for Science Plan

- The 8th GEWEX Science Conference (6-11 May 2018 @Canmore Canada)
- JpGU 2018, Post MAHASRI session (20 May 2018 @Makuhari Chiba)
- Post MAHASRI Science Plan Core Workshop (Oct. 2018)
- GHP/Andex Workshop (Oct. 2018)
- Drafting / Work Groups 0-6
- Propose new RHP
- Post MAHASRI International SSG Meeting (11 Nov. 2018) just before ACRE Japan (12-16 Nov 2018, Tokyo)
Post-MAHASRI and TPE

- Development of TPE project around Tibetan Plateau
  - **TPE: Third Pole Environment**
  - TPE will join as a cross cutting of GHP
    - ‘TPE Water-Sustainability Crosscutting’
    - Collaboration of PostMAHASRI and TPE under GHP?
  - Post-MAHASRI and TPE is seeking collaboration
    - AMY-Reanalysis
    - Downscaling modeling research focused on southern slope of Tibet
  - Impacts of Tibetan Plateau is commonly important
  - Collaboration including Cryosphere researchers is expected
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
Objectives of the Post MAHASRI

General Objective

- Understanding of Asian Land Precipitation over Diverse Hydroclimatological Conditions: For Better Prediction, Disaster Reduction and Sustainable Development.

Key Science Issues

- Impacts of Diversed Land Surface: Topography, Cryosphere, Vegetation, Land Use and Coast Lines on Diurnally Varying Precipitation Process
- Hydrological Modeling which Incorporates Human Water Withdrawal and Impacts of Agricultural Activity and Biosphere in Monsoon Asia
- Targeted and Integrated Observation Projects Coordinated with New Generation High Resolution Dataset, Modeling, Radar Network, and Satellites / Coordinated Regional Process Studies
- Playing a Key Role in S2S (Sub-seasonal to Seasonal) Prediction Project
- Data Rescue for 200-Year Climate Change Detection: with ACRE
- Regional Climate Projection and Dynamic and Statistical Downscaling Collaborating with Modeling Community including CORDEX
Research Strategy

- We Focus on
  - **Reality**: In-situ/Remote Observation and Monitoring
  - **Science**: Applications Based on Better Understanding
  - **Unknown**: Land-Boundary Layer-Atmosphere Interaction

- Three Time Scales
  - **Subseasonal** to **Seasonal (S2S)** Prediction
  - **Interannual** to **Interdecadal** Prediction
  - **Climate** Projection
S2S Predictability and Land Surface

- Role of Land Surface for Predictability at different Time Scales

Mariotti et al (2018)
Research Strategy

- We Focus on
  - **Reality**: In-situ/Remote Observation and Monitoring
  - **Science**: Applications Based on Better Understanding
  - **Unknown**: Land-Boundary Layer-Atmosphere Interaction

- Three Time Scales
  - Subseasonal to Seasonal (S2S) Prediction
  - Interannual to Interdecadal Prediction
  - Climate Projection

- Model Improvement (High-Resolution / Land Surface)

- Asian Monsoon: System-Subsystem Interaction
  - Regional Process Studies
  - Integrated Behavior of Asian Monsoon System
Climate systems that interact with regional hydroclimate systems over monsoon Asia
Reginal Hydroclimate Systems

- Post MAHASRI will conduct process studies for diverse regional hydroclimate systems
Scientific Approaches

To Understand Asian Monsoon Land Precipitation,

1. Observation and Estimation of Variation and Extremes in Asian Land Precipitation and Important Variables
2. Process Studies of Asian Land Precipitation Focusing on Diverse Land-Atmosphere Interactions
3. Understanding and Prediction of Variability of Asian Monsoon from Subseasonal to Interdecadal Time Scales
4. High Resolution Land Surface Hydrological Modeling and Monitoring Incorporating Impacts of Human Water Withdrawal, Agriculture, Vegetation and Cryosphere
5. Coordinated Observation and Modeling Initiatives
6. Detection and Projection of the Climate Change Impact on Regional Precipitation in the Asian Monsoon Region
GEWEX Science Imperatives

- **Data Sets**: Foster development of climate data records of atmosphere, water, land, and energy-related quantities, including metadata and uncertainty estimates.
- **Analysis**: Describe and analyze observed variations, trends, and extremes (such as heat waves, floods, and droughts) in water and energy-related quantities.
- **Processes**: Develop diagnostic approaches to improve process-level understanding of energy and water cycles in support of improved land and atmosphere models.
- **Modeling**: Improve global and regional simulations and predictions of precipitation, clouds, and land hydrology, and thus the entire climate system, through accelerated development of models of the land and atmosphere.
- **Applications**: Attribute causes of variability, trends, and extremes, and determine the predictability of energy and water cycles on global and regional bases in collaboration with the wider WCRP community.
- **Transfer**: Develop diagnostic tools and methods, new observations, models, data management, and other research products for multiple uses and transition to operational applications in partnership with climate and hydrometeorological service providers.
- **Capacity Building**: Promote and foster capacity building through the training of scientists and outreach to the user community.
WCRP Grand Challenges

- Melting Ice and Global Consequences
- Clouds, Circulation and Climate Sensitivity
- Carbon Feedbacks in the Climate System
- Weather and Climate Extremes
- Water for the Food Baskets of the World
- Regional Sea-Level Change and Coastal Impacts
- Near-term Climate Prediction
GEWEX Science Questions (2013)

- Observations and Predictions of Precipitation:
  - How can we better understand and predict precipitation variability and changes?

- Global Water Resource Systems:
  - How do changes in land surface and hydrology influence past and future changes in water availability and security?

- Changes in Extremes:
  - How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?

- Water and Energy Cycles and Processes:
  - How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?
Outline

- Towards Establishment of the Science plan of Post-MAHASRI RHP
  - RHPs over the Monsoon Asia -- GAME / MAHASRI
  - Outcomes of MAHASRI
  - Recent Post-MAHASRI planning activities
  - Objectives, Key Science Issues and GEWEX Framework
  - Current Research Topics
Soil moisture impact on precipitation

- Impacts of Land Surface on Diurnally Varying Precipitation in Bangladesh Monsoon and Pre-monsoon Seasons

According to Sugimoto and Takahashi (2017), dry and wet soil conditions have different impacts on rainfall. In dry conditions, rainfall tends to be wetter and stronger, while in wet conditions, it is drier and stronger. TheDry run

Rainfall Frequency (Wet – Dry run)

06-09LT 09-12LT 12-15LT 15-18LT 18-21LT 21-00LT 00-03LT 03-06LT

Local Time

- Drier
- Stronger
- Wetter
- Stronger
Diurnal Variation of Coastal Rain

Mean wind profile perpendicular to the coastline

Composite for 8 days with clear offshore migration

Composite for other 19 days

Low-level offshore-ward vertical shear, which is important for regeneration of convective cells offshore, was observed only in days with clear offshore migration, only over coastal waters.

May 20, 2018, by Satoru Yokoi (JAMSTEC)
• Hot extreme events have increased around Mongolia and eastern Europe
• Positive feedback bw L-A is initiated and intensified under preferable synoptic condition

JJA $T_{air}$ change (JRA55)

Trend in 1979-2013 summer surface hot extremes (d yr$^{-1}$ yr$^{-1}$)

Internal variability

Initial perturbation

High pressure (+)

Sensible heat (+)

Cloud, Convection (-)

Precipitation (-)

Drought, Fire

Heat wave (+)

Soil moisture (-)

Radiation (+)

Irrigation

Cloud, Convection (-)

Precipitation (-)

Heat wave (+)

Soil moisture (-)

Drought, Fire

JJA $T_{air}$ change (JRA55)
Construction of Radar Network

BRAIN: Borderless Radar Information Networking over South and Southeast Asia

Sources of tropical cyclone tracks: JTWC and RSMC Tokyo Typhoon Center

Courtesy of Dr. Kamimera
TRMM Validation by RG Network

- Monsoon (Jun.-Sep.): Significant underestimation

Terao et al. (2017/SOLA)
Hydrological model which incorporates human water withdrawal. -> Impacts on S2S prediction? (Hanasaki et al. 2018, HESS)

There is still 21% ‘Unspecified sources’ in global water use.

Major part of unspecified is in Asia, probably from irrigation.

Validation and improvement by using various sources of information in Asia (e.g., satellite data, local data, assimilation?)

Water sources by region (Hanasaki et al., 2017)
Coast Line and Water Budget

- Mori et al. (2004), Ogino et al. (2016, 2017)

Water vapor transport

<table>
<thead>
<tr>
<th>Open Ocean</th>
<th>Coastal Region</th>
<th>Inland</th>
</tr>
</thead>
<tbody>
<tr>
<td>P &lt; E 401</td>
<td>P &gt; E 121 99</td>
<td>P &gt; E 86 63</td>
</tr>
</tbody>
</table>

Direct fresh water supply

45 dehydration process

35 River & groundwater discharge

Water vapor transport

22
Boundary Layer -> Tropopause

Boos and Kuang (2010)

By Terao

Silk Road Pattern

Wave breaking

ERA40 $\theta_e$ @ 20hPa σ
Nocturnal LLJ

- Fujinami et al. (2017), Terao et al. (2006)
Summary

- New platform for RHP activity over the Monsoon Asia is now in the planning phase
- A tentative Objectives and Approaches was presented as a starting point of the discussion
- Science Plan is targeted on the next GEWEX Panel on 22-26 Oct. @ Santiago, Chile
AMY-II, 2020

- Coordinated Observation and Modeling Initiatives