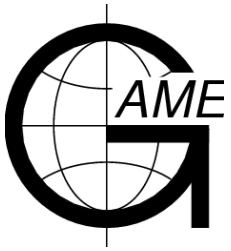
11 Oct. 2018: Annual Workshop on
Science of Climate Change @ IITG/Pune



Post MAHASRI Initiative

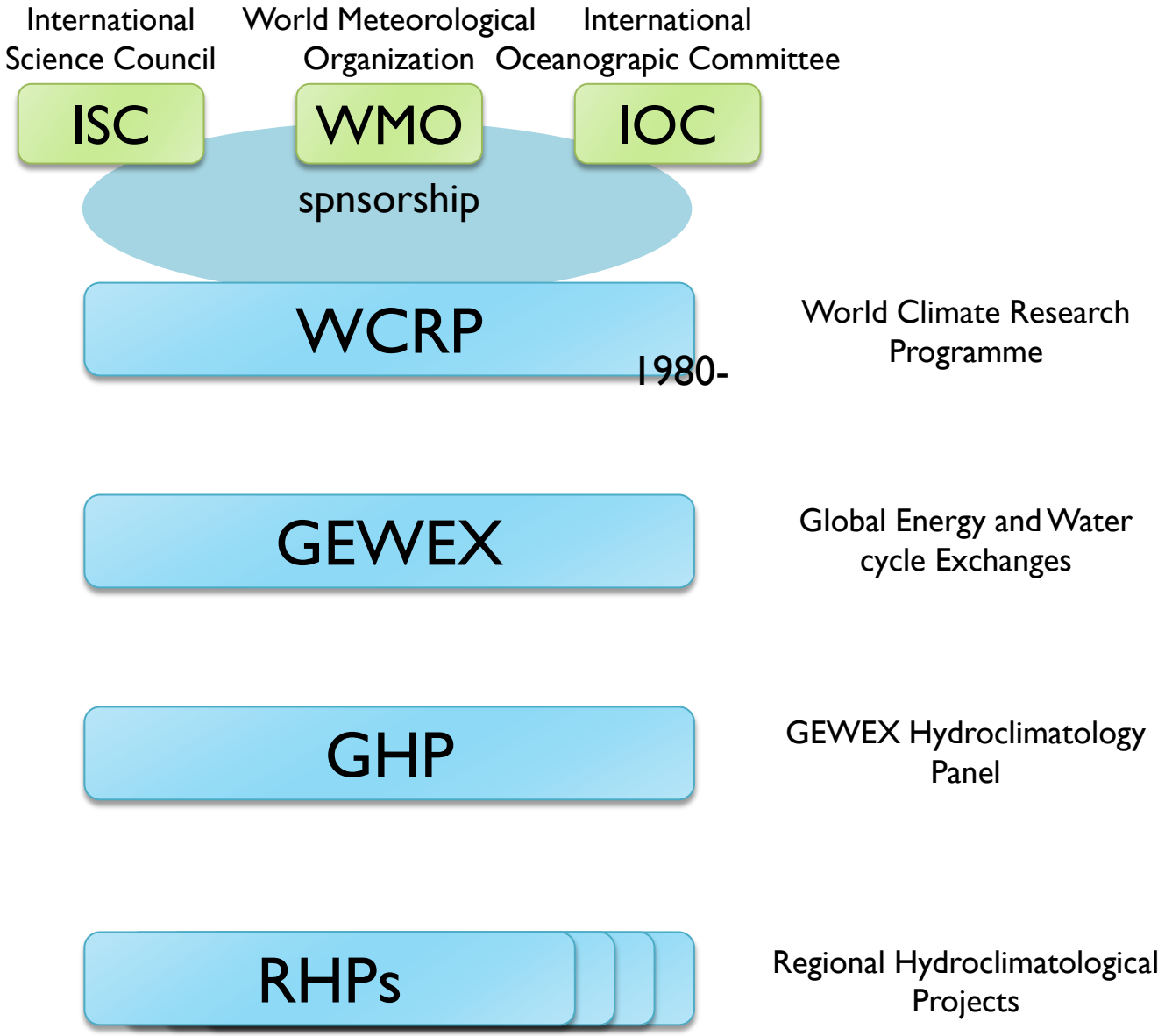
Toru Terao (Kagawa University)

Outline

- Regional Hydroclimatological Project
- Post MAHASRI Project
- South Indian Project in the AMY(Asian Monsoon Year)-II initiative scheduled in 2020: A Coordinated Observation Project for Asian Monsoon

What is RHP (Regional Hydroclimatological Project)?

Section 1


International Science Council
World Meteorological Organization
International Oceanograpic Committee
ISC
WMO
IOC
spnsorship
WCRP
1980-
World Climate Research Programme
GEWEX
Global Energy and Water cycle Exchanges
GHP
GEWEX Hydroclimatology Panel
RHPs
Regional Hydroclimatological Projects

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
North America: ***CCRN*** (2014-2018) => Cryospheric, ecological, hydrological interactions

Recently finished:

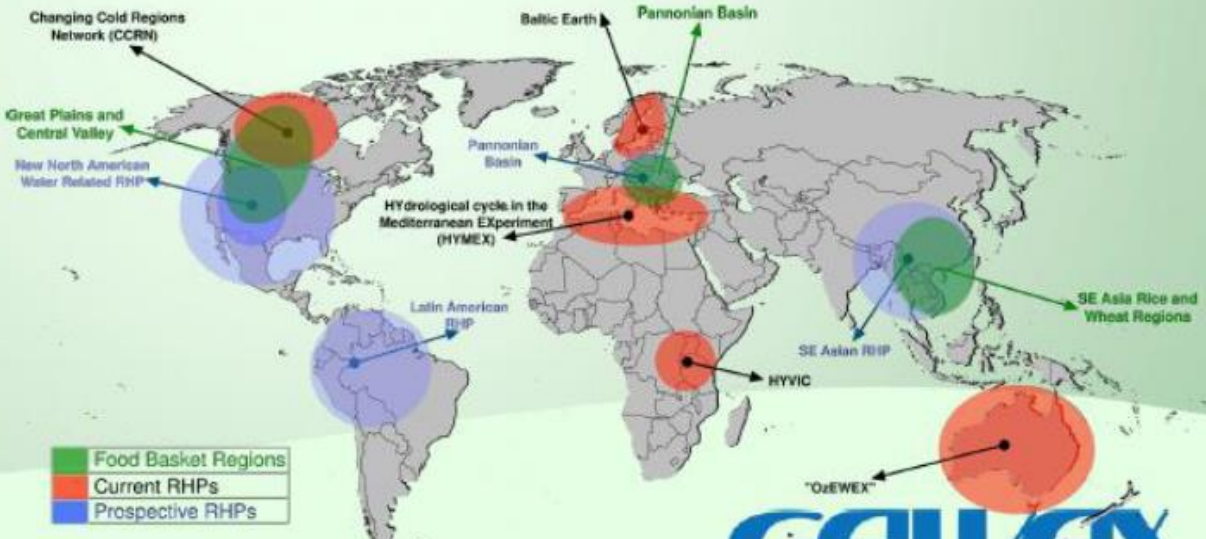
Asia: ***MAHASRI*** (2007-2016) ======> Asian Monsoon
Eurasia: ***NEESPI*** (2004-2015) =====> Northern Eurasian climate-ecosystem-societal interac

Prospective:

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

In discussion:

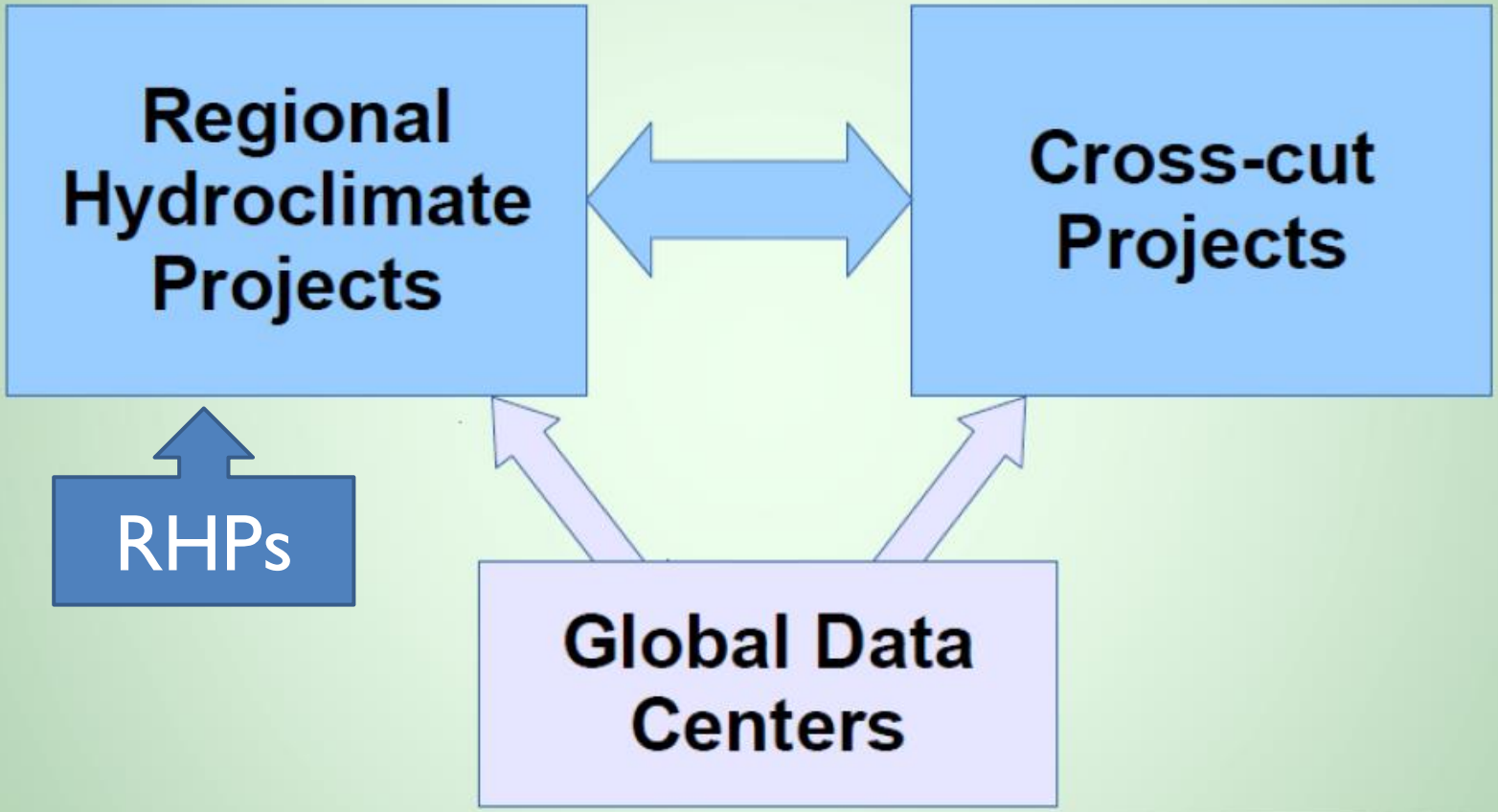
Exploring possibilities
in the Americas and Asia.



(Courtesy of Prof. Jason Evans, Co-chair of GHP)

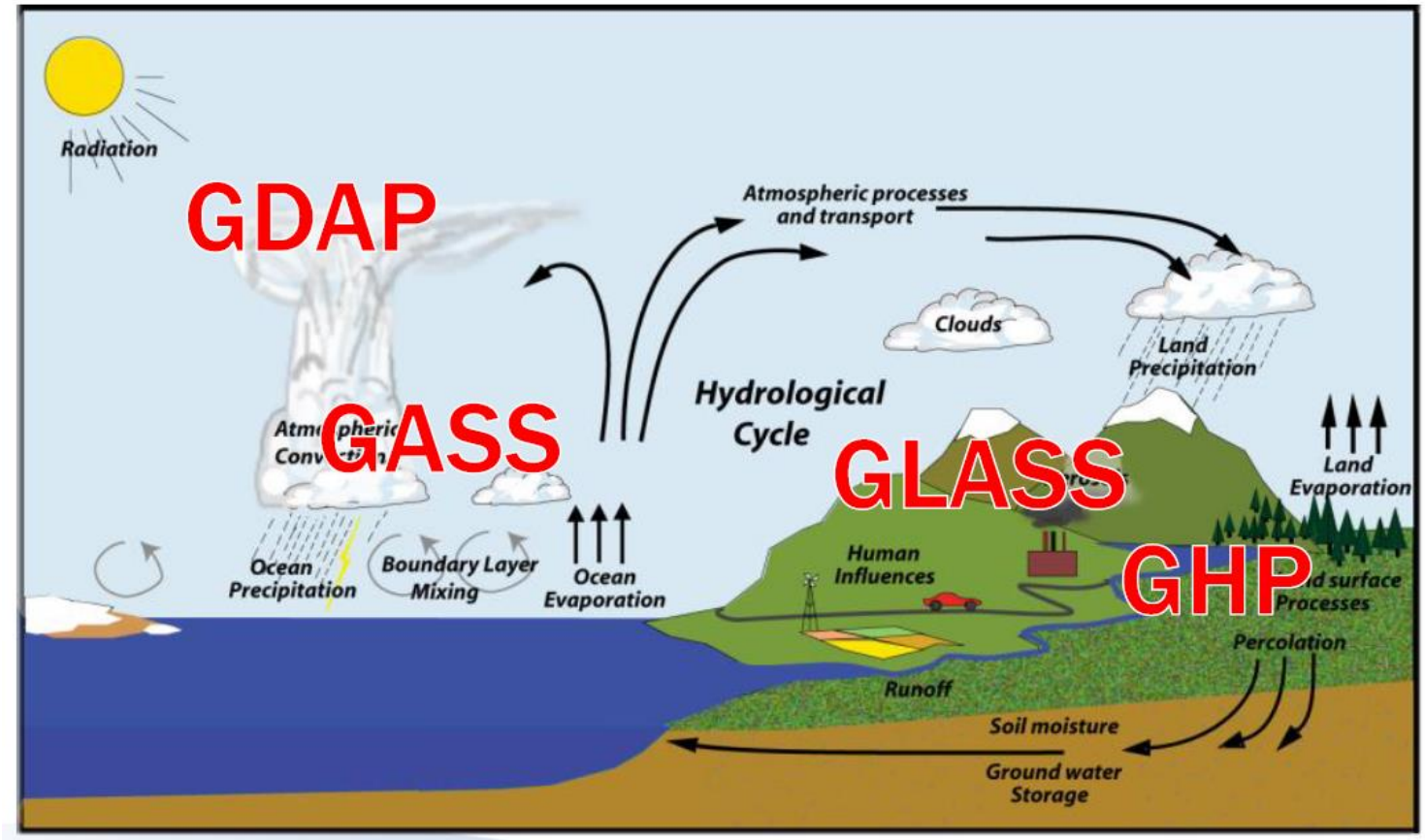
GHP Structure

GHP: GEWEX Hydroclimatology Panel



(Courtesy of Prof. Jason Evans, Co-chair of GHP)

Sub-components of GEWEX

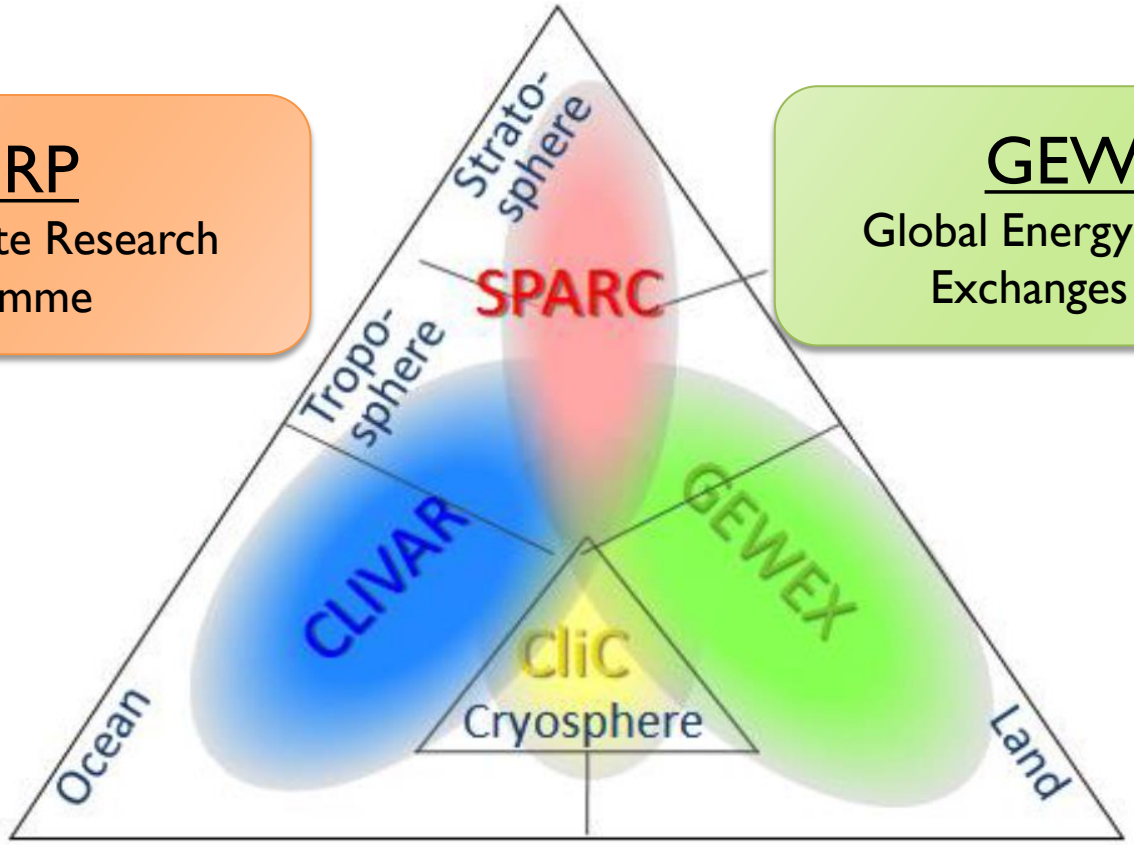


From slides of Prof. Matsumoto

WCRP / GEWEX

GEWEX within WCRP

WCRP
World Climate Research Programme



GEWEX
Global Energy and Water Exchanges Project

From slides of Prof. Matsumoto

RHP Criteria (Sep. 2013)

- GEWEX Scientific Steering Group (SSG)
  - Assesses and approves Project Plans
- RHPs should state
  - the central science and applications questions, and
  - how to contribute the seven "GEWEX Science Imperatives",
    - Data sets, Analysis, Processes, Modeling, Applications, Technology Transfer, and Capacity Building
  - "WCRP Grand Challenges" & "GEWEX Science Questions"
- RHPs should include
  - …

Next Feb.-Mar.

RHP's Science Plan

Introduction to Post MAHASRI Science Plan

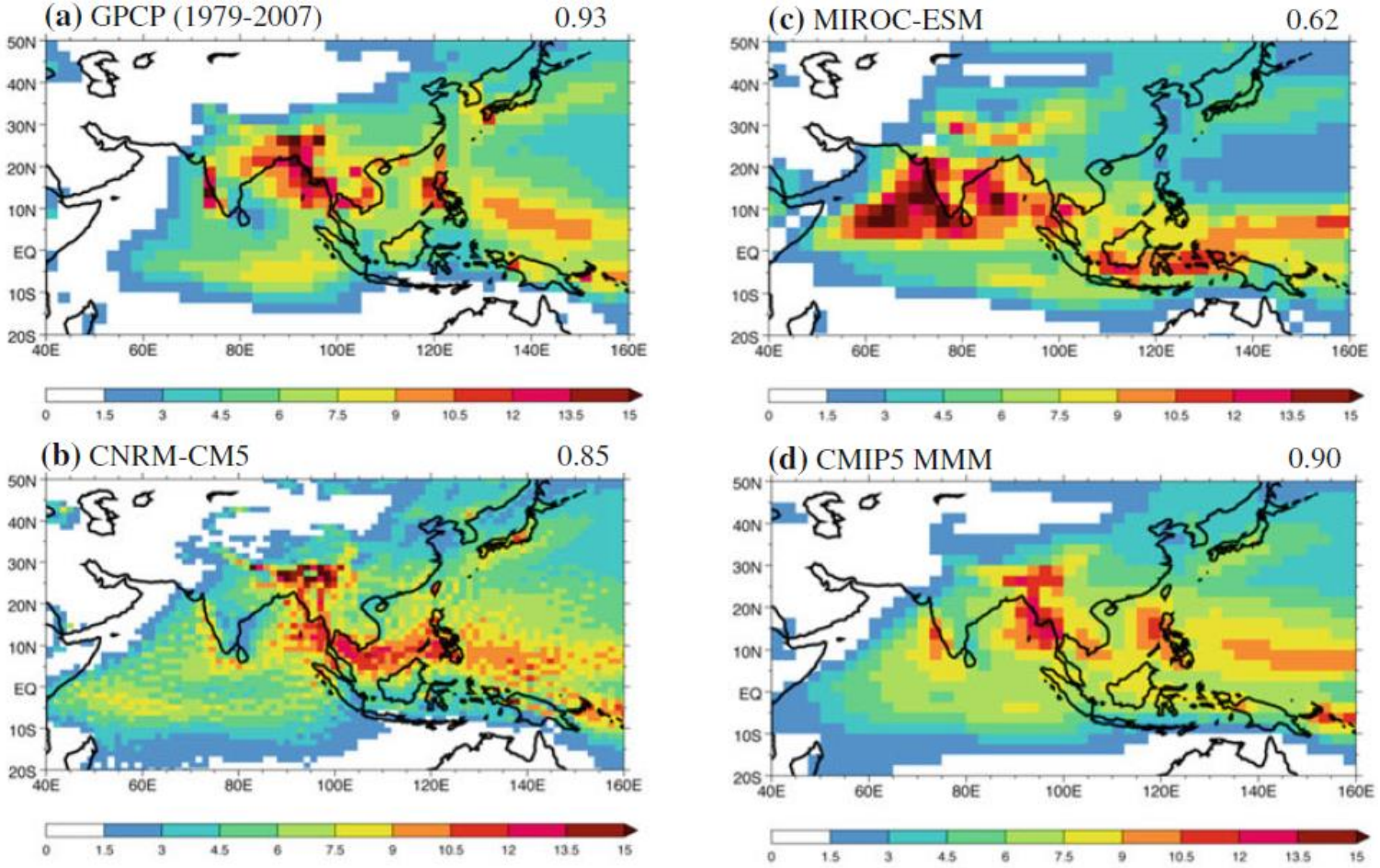
Section 2

Introduction to Post MAHASRI

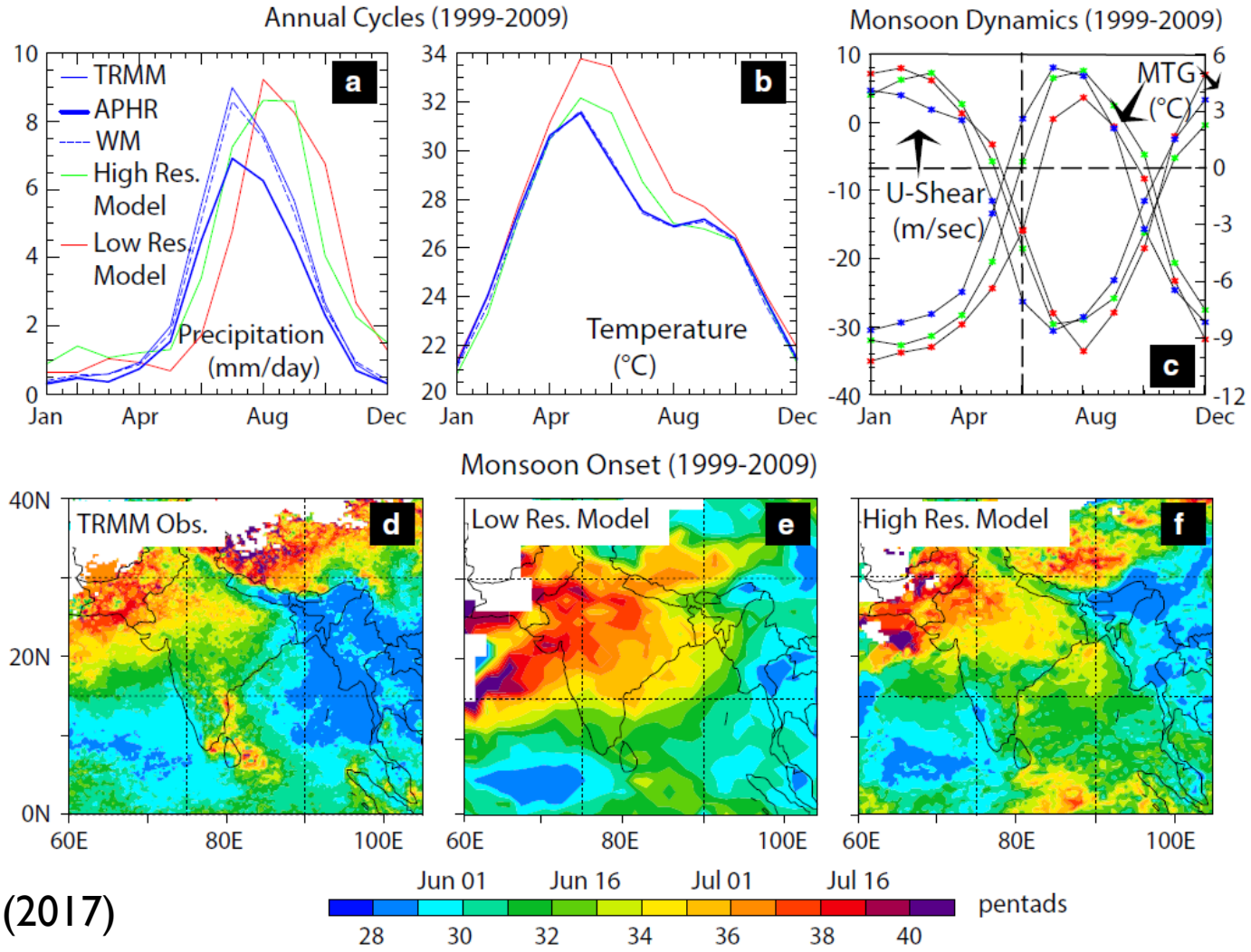
- Why Asian land precipitation?
  - Huge population / climate change / disasters / human life / food basket are depend on Asian land precipitation
  - Huge unknown --- Science is needed
    - Insufficient representation of monsoon prec. in climate models
    - Impact of human water withdrawal
    - Land surface impact on precipitation
    - Precipitation prediction in S2S and interannual scales
    - Highland precipitation
- What is Asian monsoon?
  - Huge land-sea breeze system or migrated ITCZ?
    - Key process: Land surface process / convection
  - Multiple time scales and diverse land impact on the atmosphere

Annual Precipitation in Climate Models

- Sperber et al. (2013)



South Asian monsoon precipitation



Asufaq et al. (2017)

- We cannot even reproduce current Asian climate and precipitation using climage models.
- For the policymakers including people, convincing result of climate models are needed.
- We cannot go further without advancement of scientific understanding of hydrometeorological processes.
- What can we do during upcoming 10 years?
  - Concrete individual research plan for scientific approaches

    ⇒ 6 Approaches
  - Croscutting questions that lead entire research project

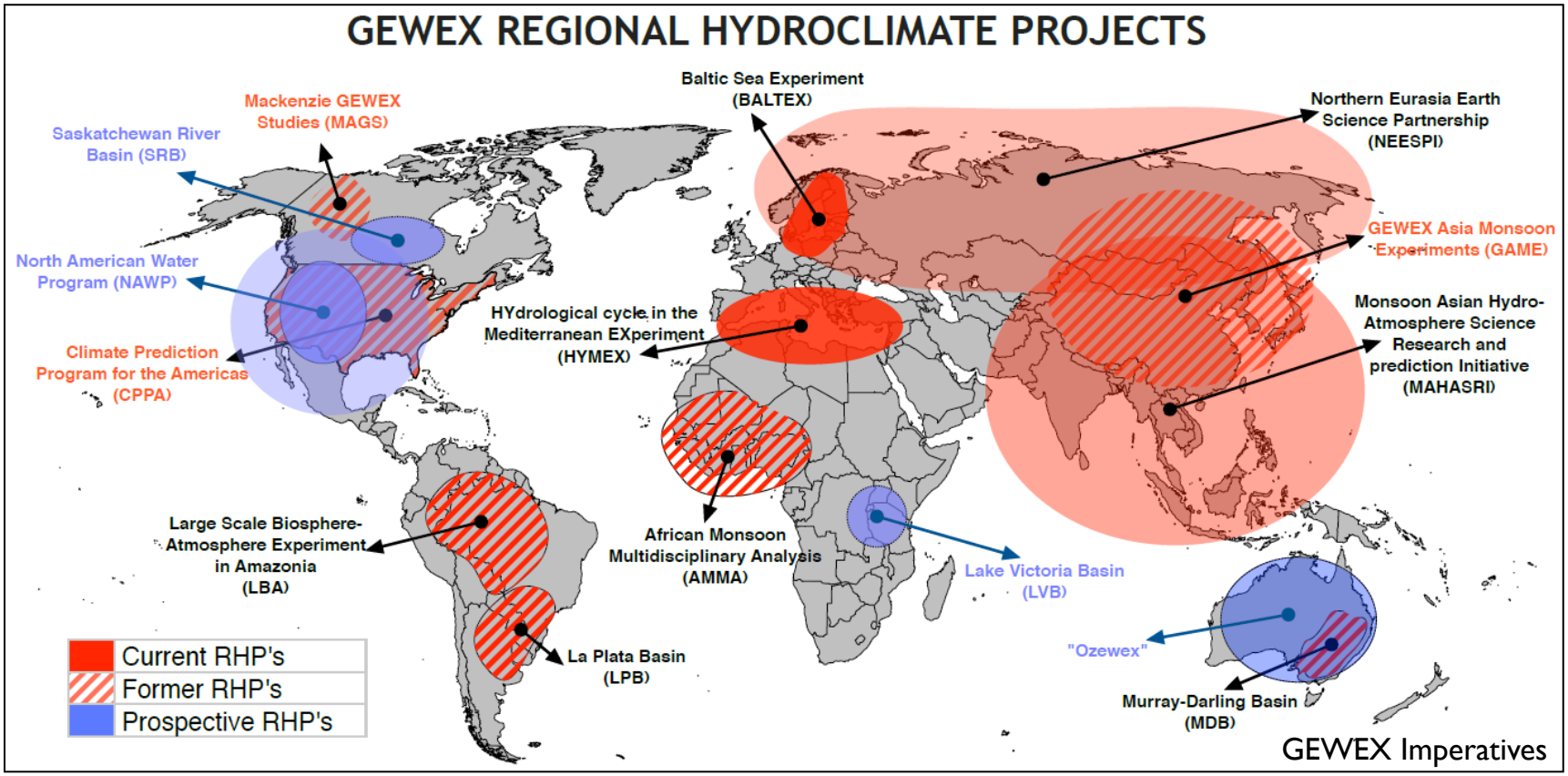
    ⇒ 5 Questions

History of Asian monsoon RHPs

- Pre-GAME
- WCRP / GEWEX / GHP / RHP Framework
- GAME / Focus and outcome
- Post MAHASRI / Focus:
  - Outcome
    - Rainfall data (gauge based gridded datasets, GPM validation, historical)
    - High-resolution hydrological modeling
    - Process studies
    - Autumn/winter monsoon, monsoon onset/withdrawal
    - AMY and Collaboration and capacity building in Asian countries
- It is the time to launch post MAHASRI!

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
  - GAME (1996-2005): GEWEX Asia Monsoon Experiments
    - Atmoshere-land surface interactions
    - Four regional components => Cross cutting (2002-2004)
      - GAME-Siberia, GAME/HUBEX, GAME-Tibet, GAME-Tropics
  - MAHASRI (2006-2016): Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative
    - Hydro-meteorological prediction system, up to a season
    - Based on collaboration of several regional projects
      - Maritime Continent, Thailand, Mongolia, Vietnam, Philippines, India, Bangladesh, …

Overview of MAHASRI

Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative(2006-2015)

http://mahasri.cr.chibau.ac.jp/

"To establish hydro-meteorological prediction system, particularly up to seasonal time-scale, through better scientific understanding of Asian monsoon variability".

Jun Matsumoto

Department of Geography, Tokyo Metropolitan University, JAMSTEC/ DCOP

International Science Conference on MAHASRI , March 2, 2016
at Tokyo Metropolitan University, Japan

Objectives:

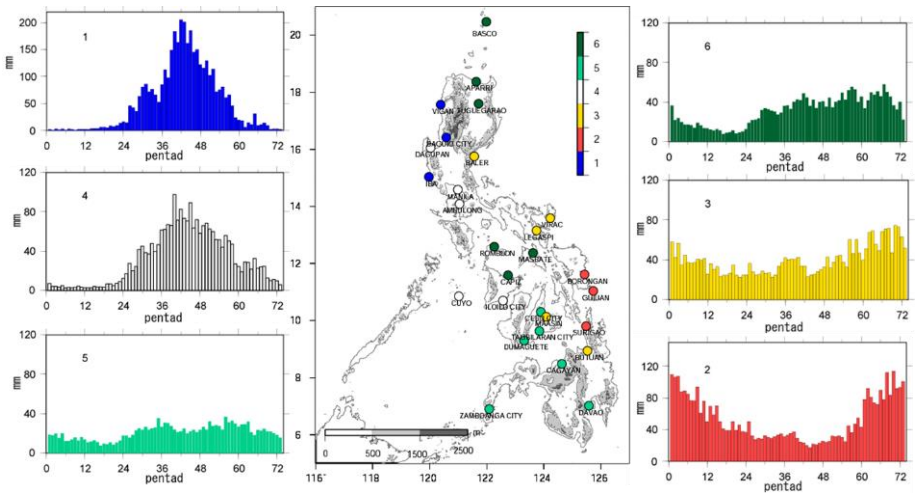
- Determining the predictability and key components of Asian monsoon variability with a time scale up to a season for the development of a hydro-meteorological prediction system.
- Developing a real-time monitoring capability for hydro-meteorological observations.
- Developing an integrated hydro-meteorological database including data rescue.
- Examining and improving the hydro-meteorological models in some specific river basins.

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.
4. Rainfall data collection and satellite validation was developed including data rescue.
5. Collaboration with AMY community.
   - Integrated Database (DIAS) in the Univ. Tokyo
   - AMY Re-analysis by MRI (Meteorological Research Institute)

Diverse monsoon season

Monsoon onset / withdrawal of Philippine and their interannual variability



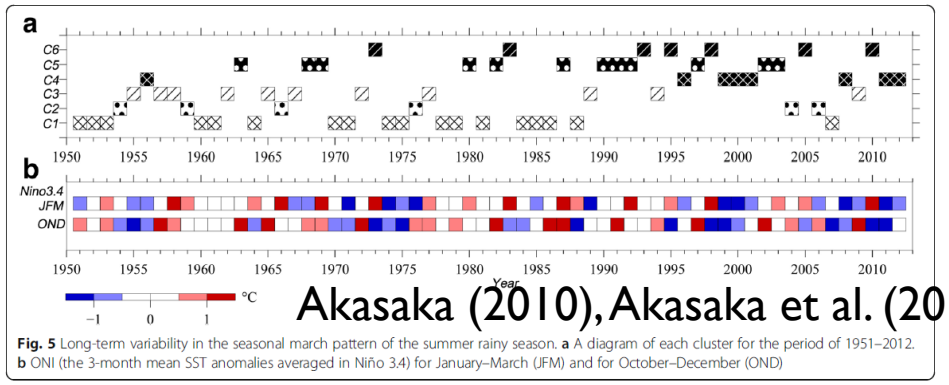
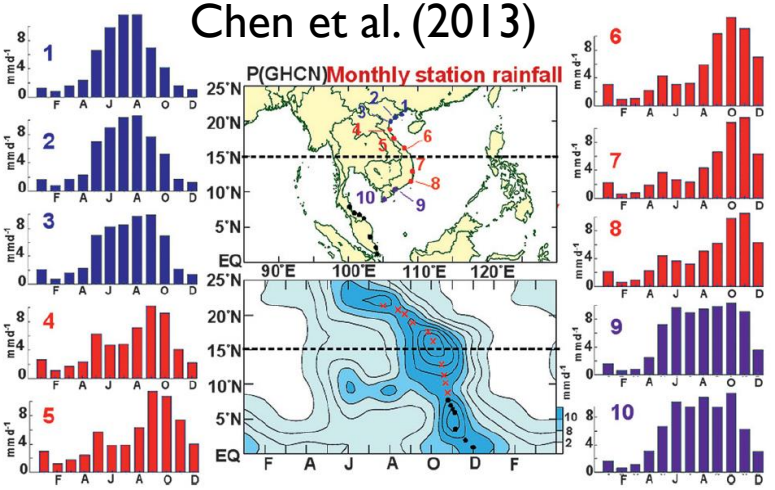


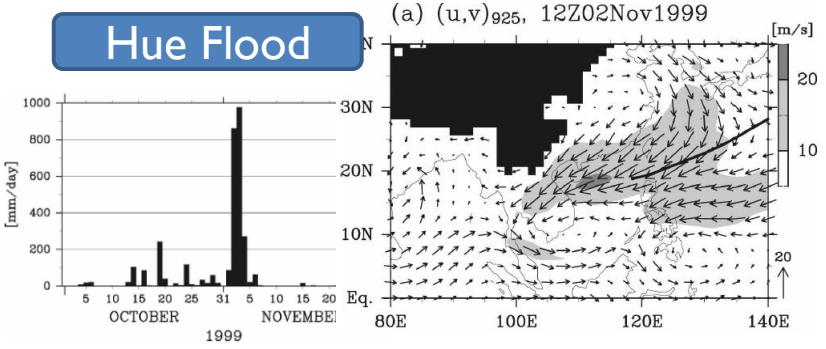
Fig. 5 Long-term variability in the seasonal march pattern of the summer rainy season. **a** A diagram of each cluster for the period of 1951–2012. **b** ONI (the 3-month mean SST anomalies averaged in Niño 3.4) for January–March (JFM) and for October–December (OND)

Akasaka (2010), Akasaka et al. (2018)

Chen et al. (2013)



Hue Flood



Yokoi and Matsumoto (2008)

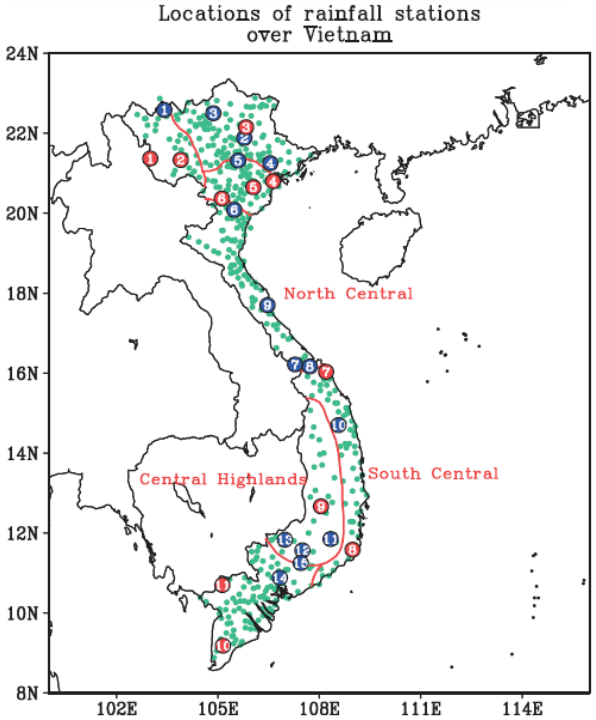
Autumn / winter monsoon in Vietnam

Impacts of MAHASRI Project

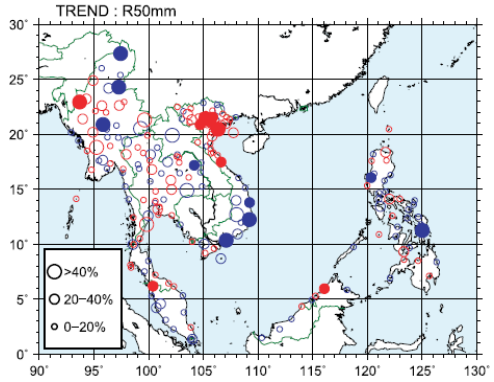
Grid-rain / Long-term Extreme Trend

VnGP: Gridded rainfall data over Vietnam

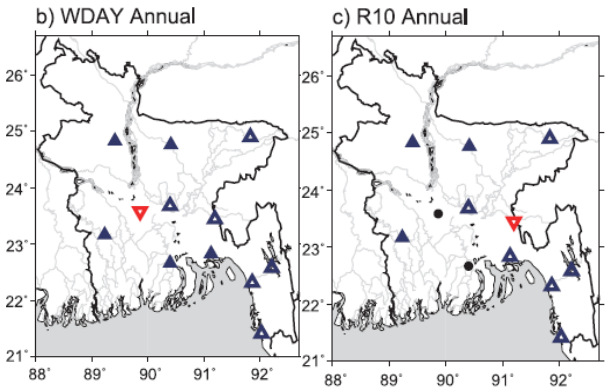
481 gauges, daily, 0.25 deg resolution, 1980-2010



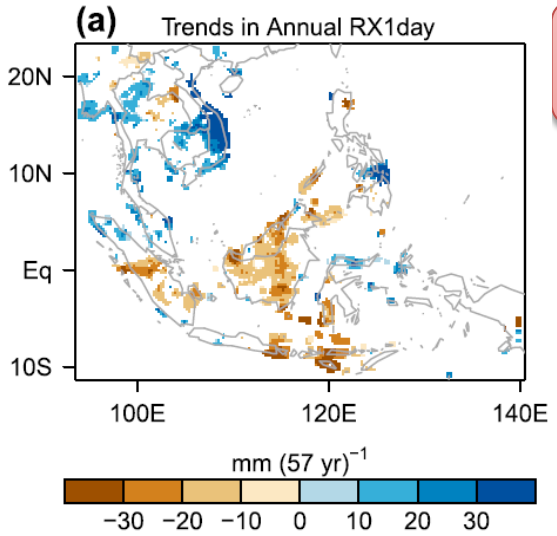
Nguyen-Xuan et al. (2016)



Endo et al. (2009)



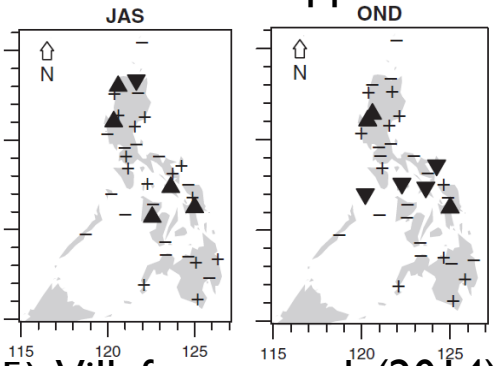
Endo et al. (2015)



Villefuerte and Matsumoto (2015)

Long-term Extreme Trends

RX5d / Philippines

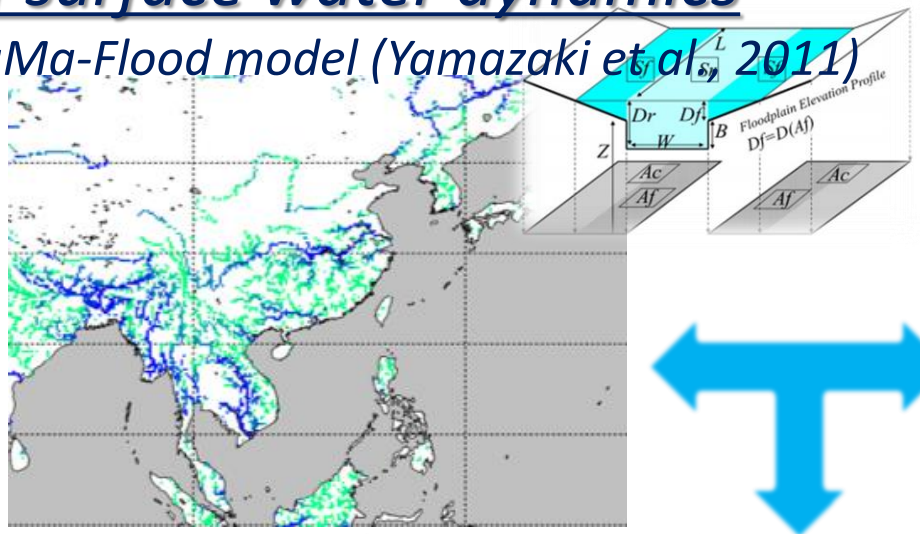


Villefuerte et al. (2014)

Integration of satellite observations and model simulations for exploring surface water dynamics

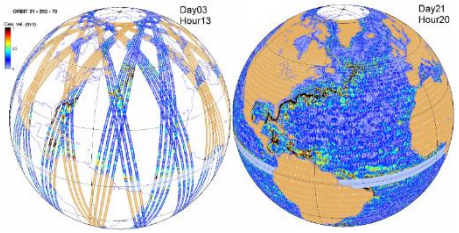
Very high resolution modeling of surface water dynamics

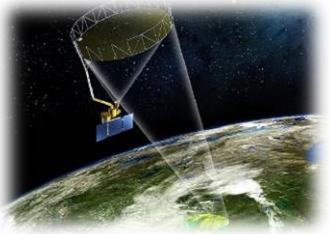
CaMa-Flood model (Yamazaki et al., 2011)



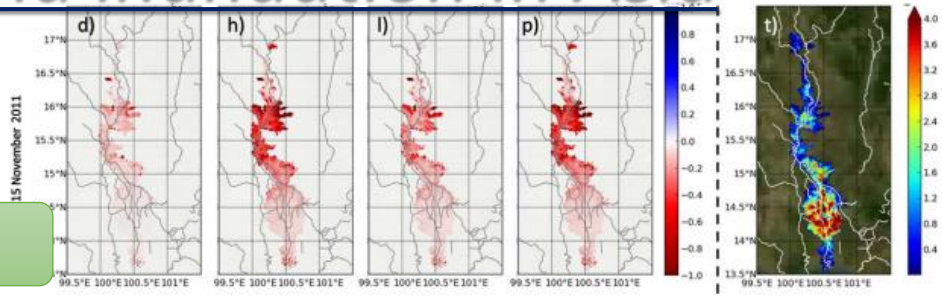
Altimeter, Microwave

SWOT, SMAP, GCOM etc.





Assimilation and Prediction of flooding and inundation in Asia

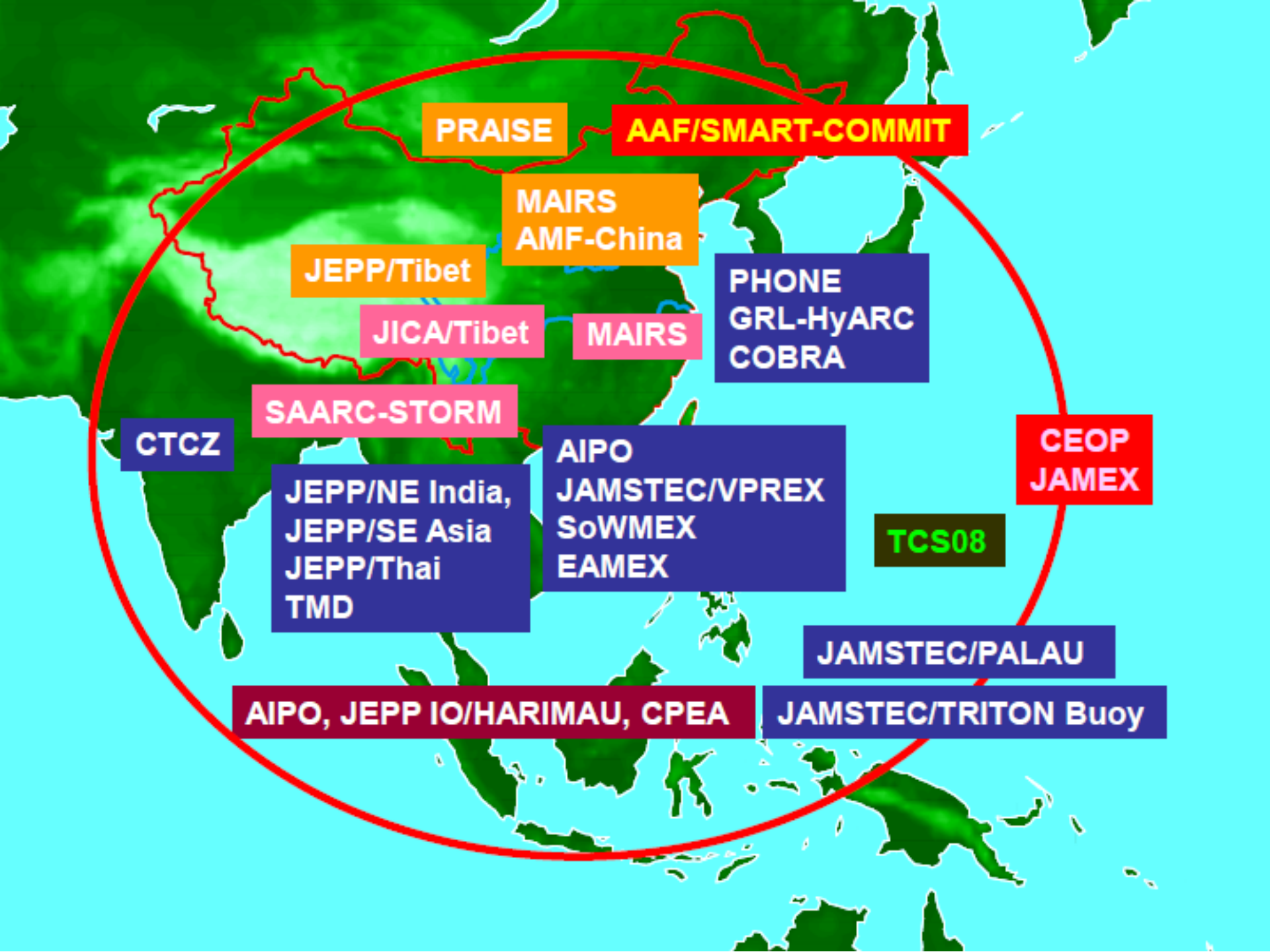


Impacts of MAHASRI Project

AMY (Asian Monsoon Years 2007-2012)

Overarching Goal:
"To improve Asian Monsoon prediction for societal benefits through improving understanding of the variability and predictability of the Asian-Australian monsoon system"

http://www.wcrp-amy.org/


PRAISE
AAF/SMART-COMMIT
MAIRS
AMF-China
JEPP/Tibet
PHONE
GRL-HyARC
COBRA
JICA/Tibet
MAIRS
SAARC-STORM
CTCZ
AIPO
JAMSTEC/VPREX
SoWMEX
EAMEX
CEOP
JAMEX
JEPP/NE India,
JEPP/SE Asia
JEPP/Thai
TMD
TCS08
JAMSTEC/PALAU
AIPO, JEPP IO/HARIMAU, CPEA
JAMSTEC/TRITON Buoy

Objectives of the Post MAHASRI

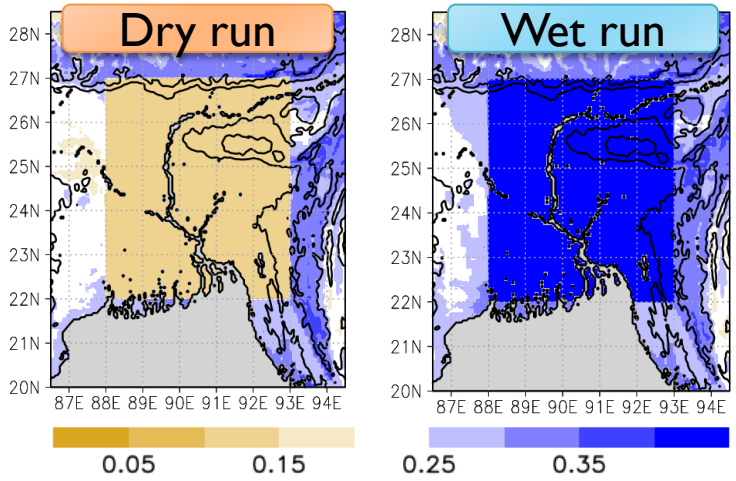
- General Objective
  - Understanding of Asian Land Precipitation over Diverse Hydroclimatological Conditions: For Better Prediction, Disaster Reduction and Sustainable Development.

What is scientific understanding?

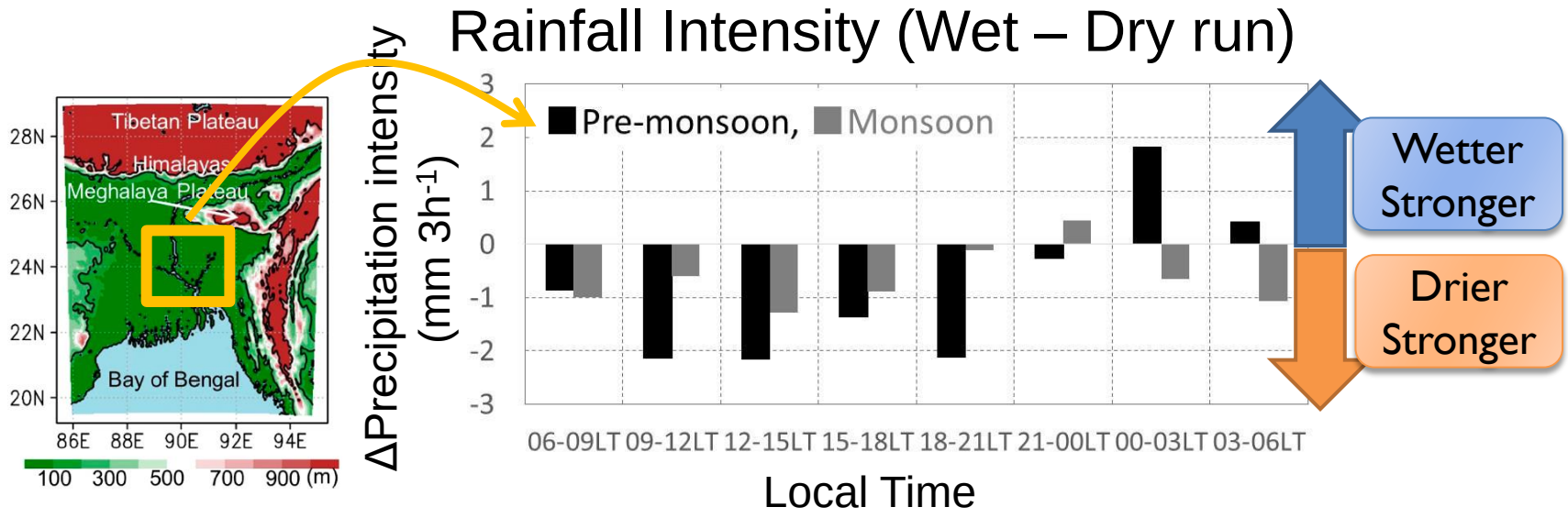
Soil moisture impact on precipitation

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

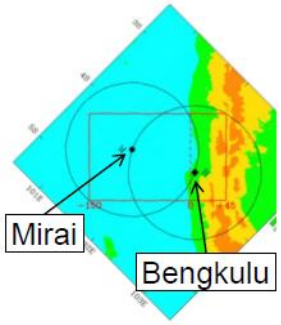
Sugimoto and Takahashi (2017)

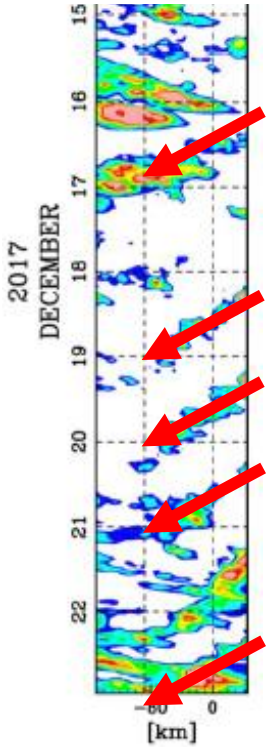


($m^3\ m^{-3}$)



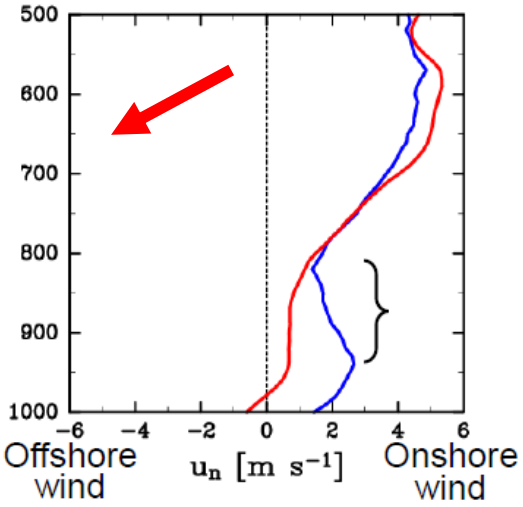
Diurnal Variation of Coastal Rain



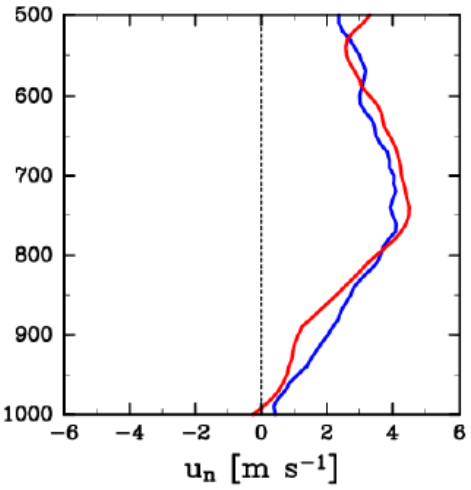


Mean wind profile perpendicular to the coastline

Composite for 8 days with clear offshore migration



Composite for other 19 days



Mirai
Bengkulu

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)

Impacts of Scientific Understanding

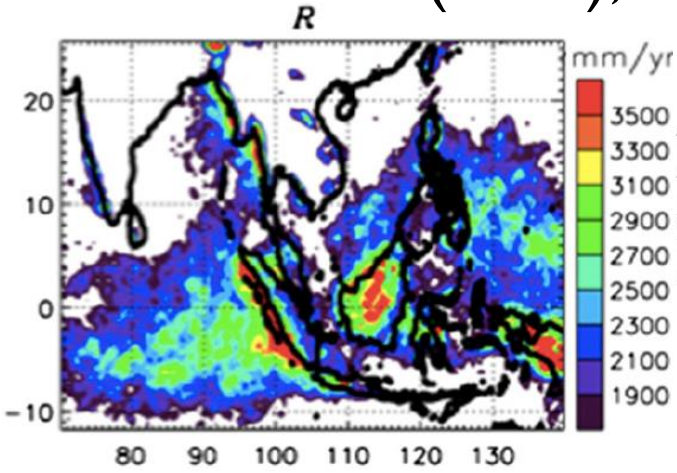
Rainfall data and satellite validation

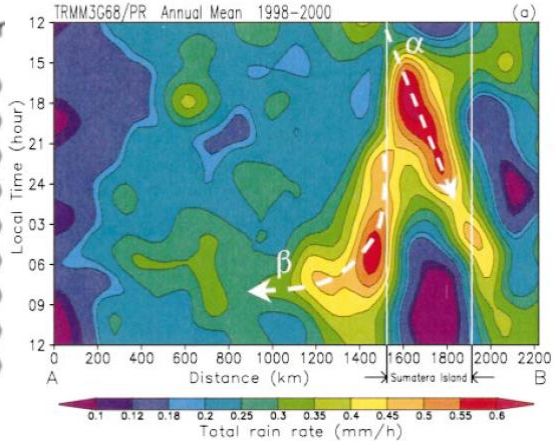
- Observation and gauge-based gridded data
  - Vietnam/0.1degs (VnGP)
  - Lowlands of Thailand/0.05degs
- Satellite (GPM) validation
  - Many validation works
  - Uncertainties in orogiraphic precipitation estimations
- Historical data reconstruction (under ACRE)

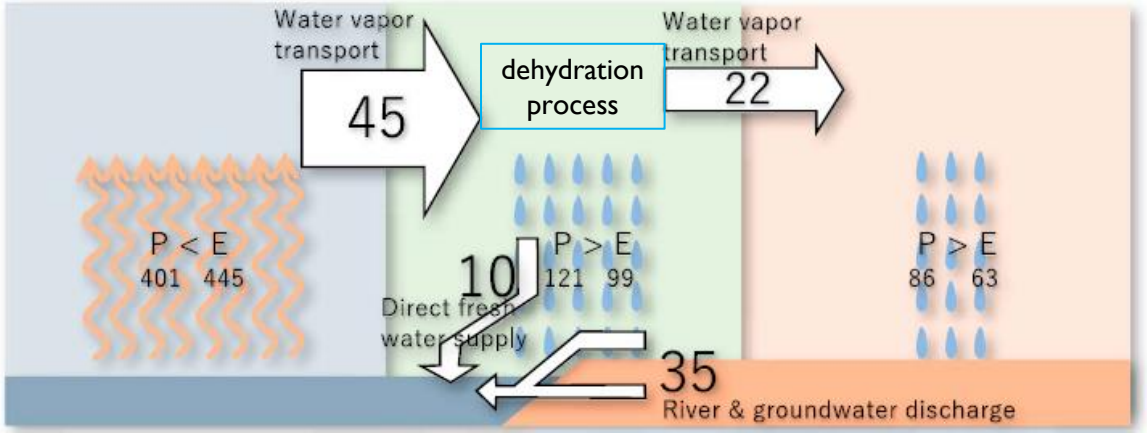
Impacts of Scientific Understanding

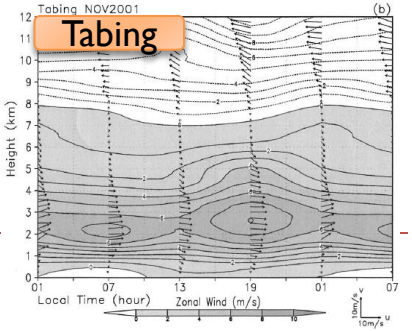
Coast Line and Water Budget

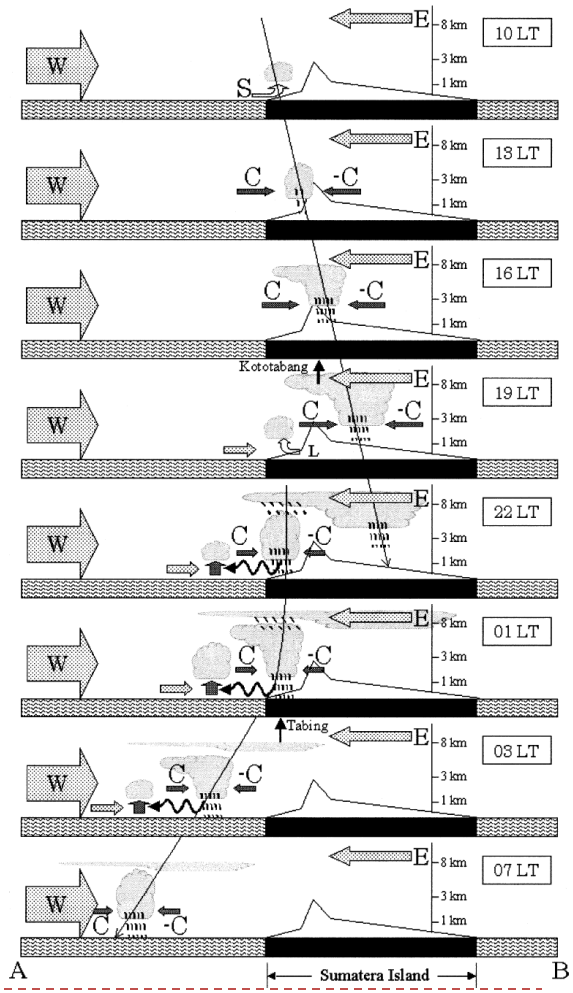
- Mori et al. (2004), Ogino et al. (2016, 2017)







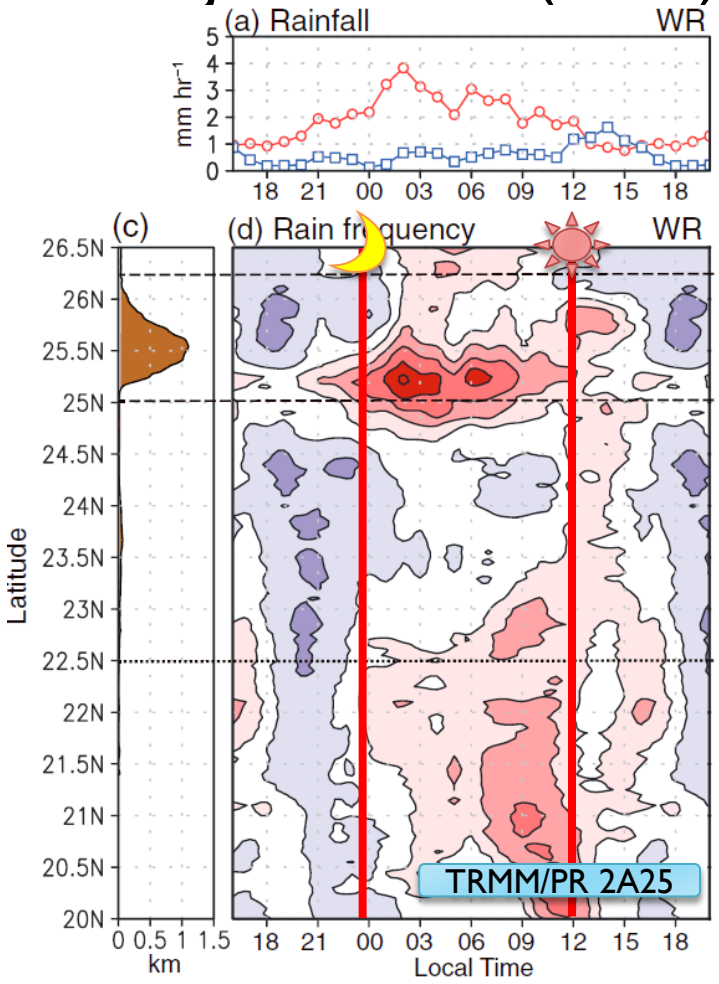


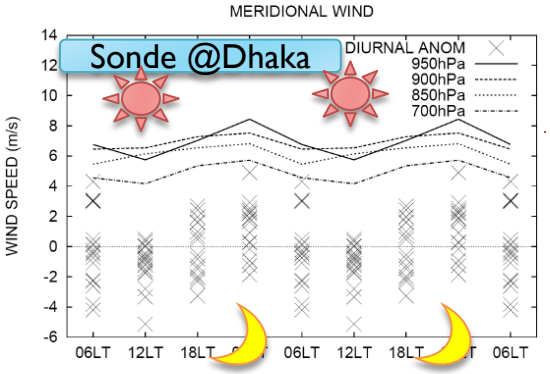


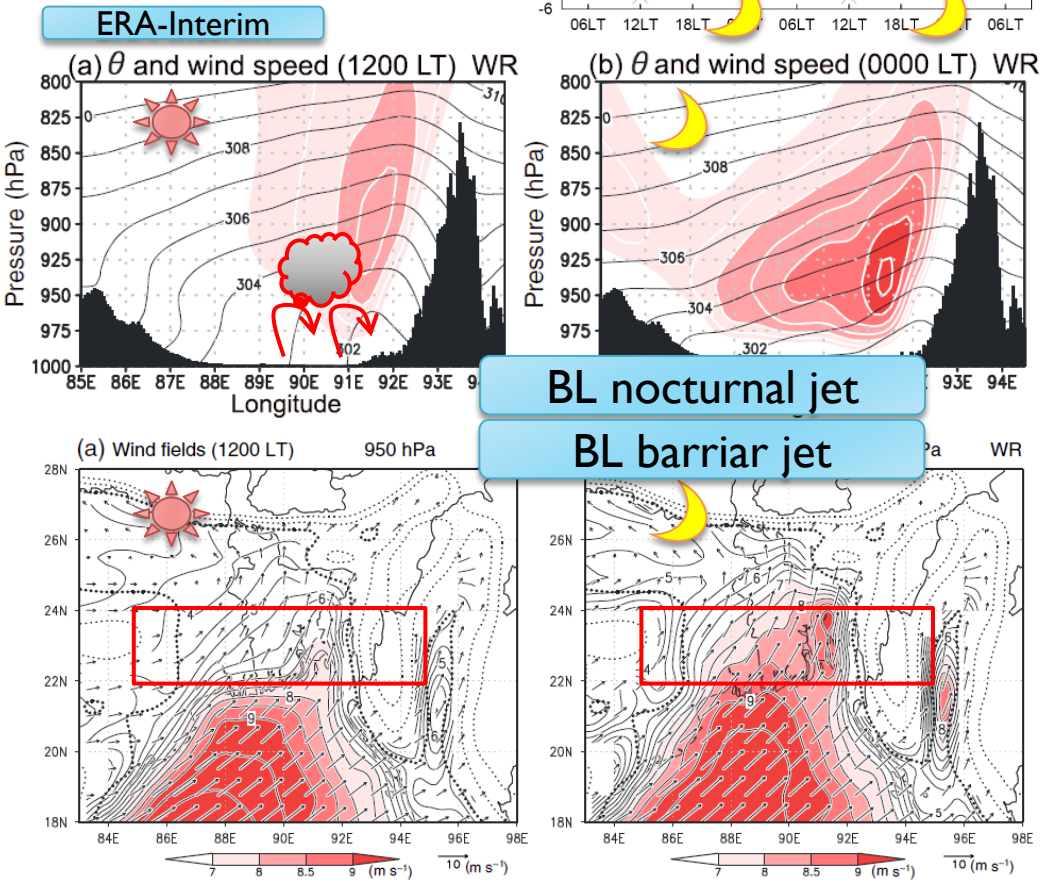
Impacts of Scientific Understanding

Nocturnal LLJ

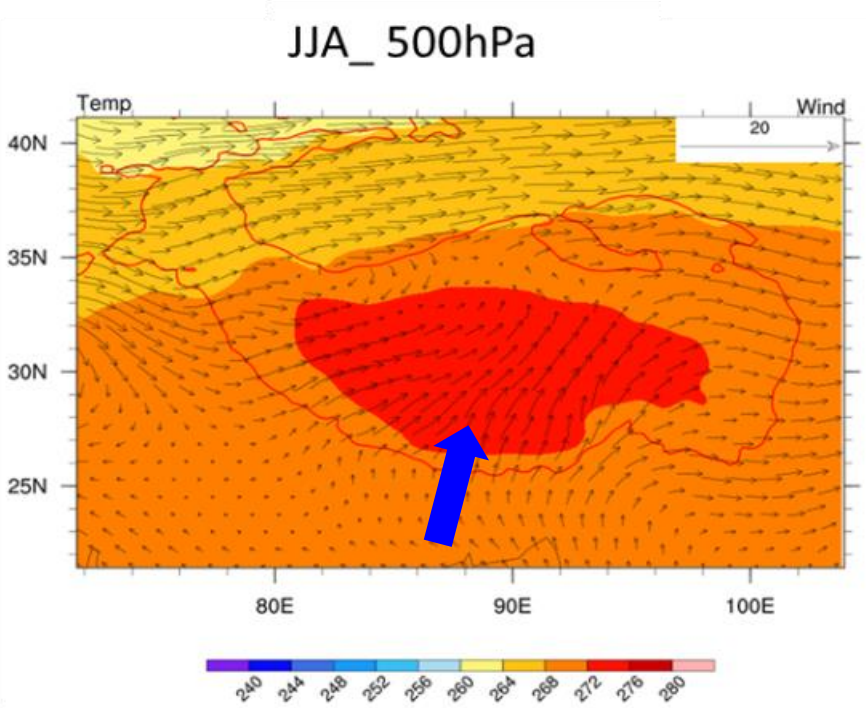
- Fujinami et al. (2017), Terao et al. (2006)

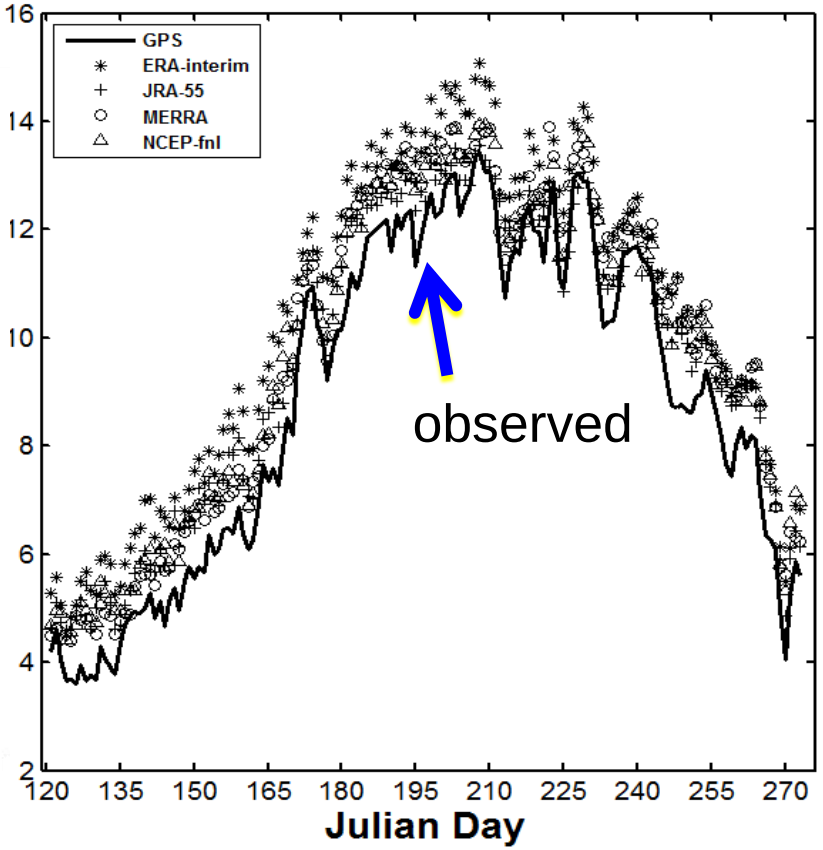






All models over-estimated precipitable water



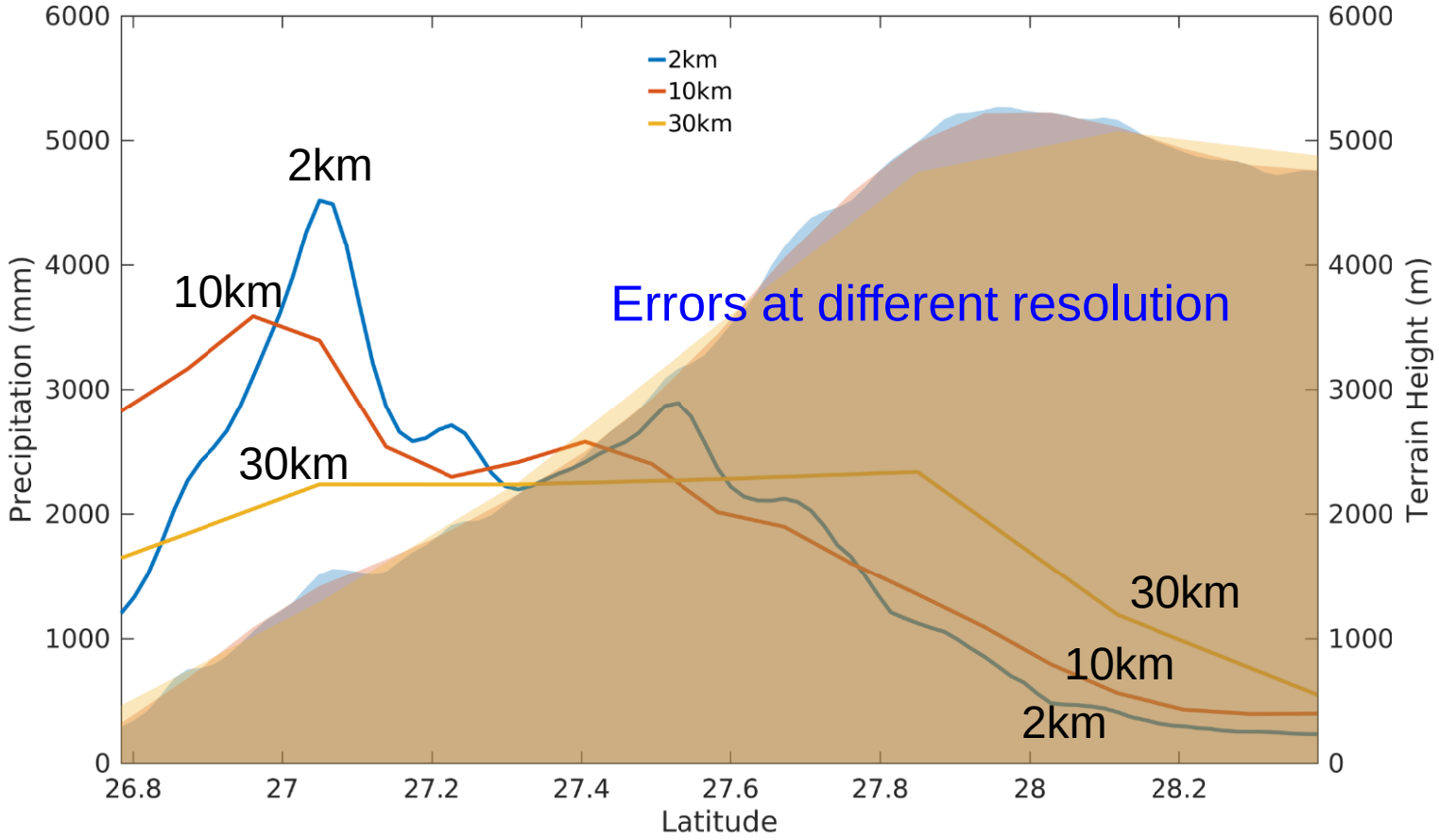


Seasonal cycle between observation and reanalyses, averaged at 9 GPS stations during 2007~2013

(Wang, Yang et al., 2017, JC)

Impacts of Scientific Understanding

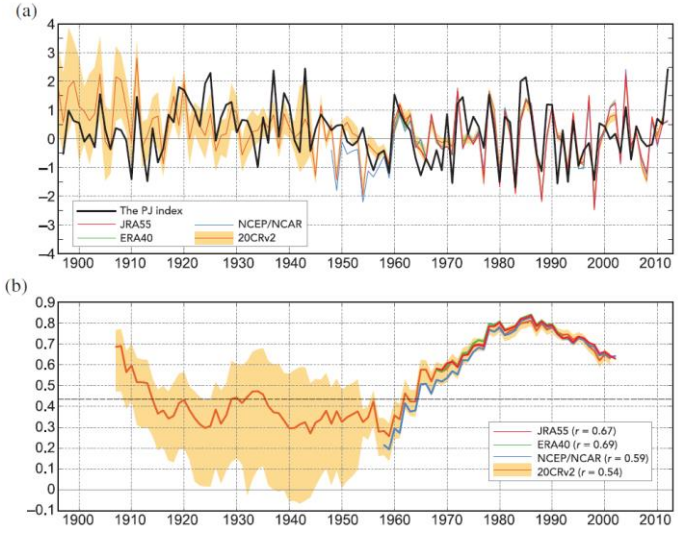
Positive biases in vapor flux results in much more precipitation in the Plateau and less in south slope



Newly emarging sceince wsves

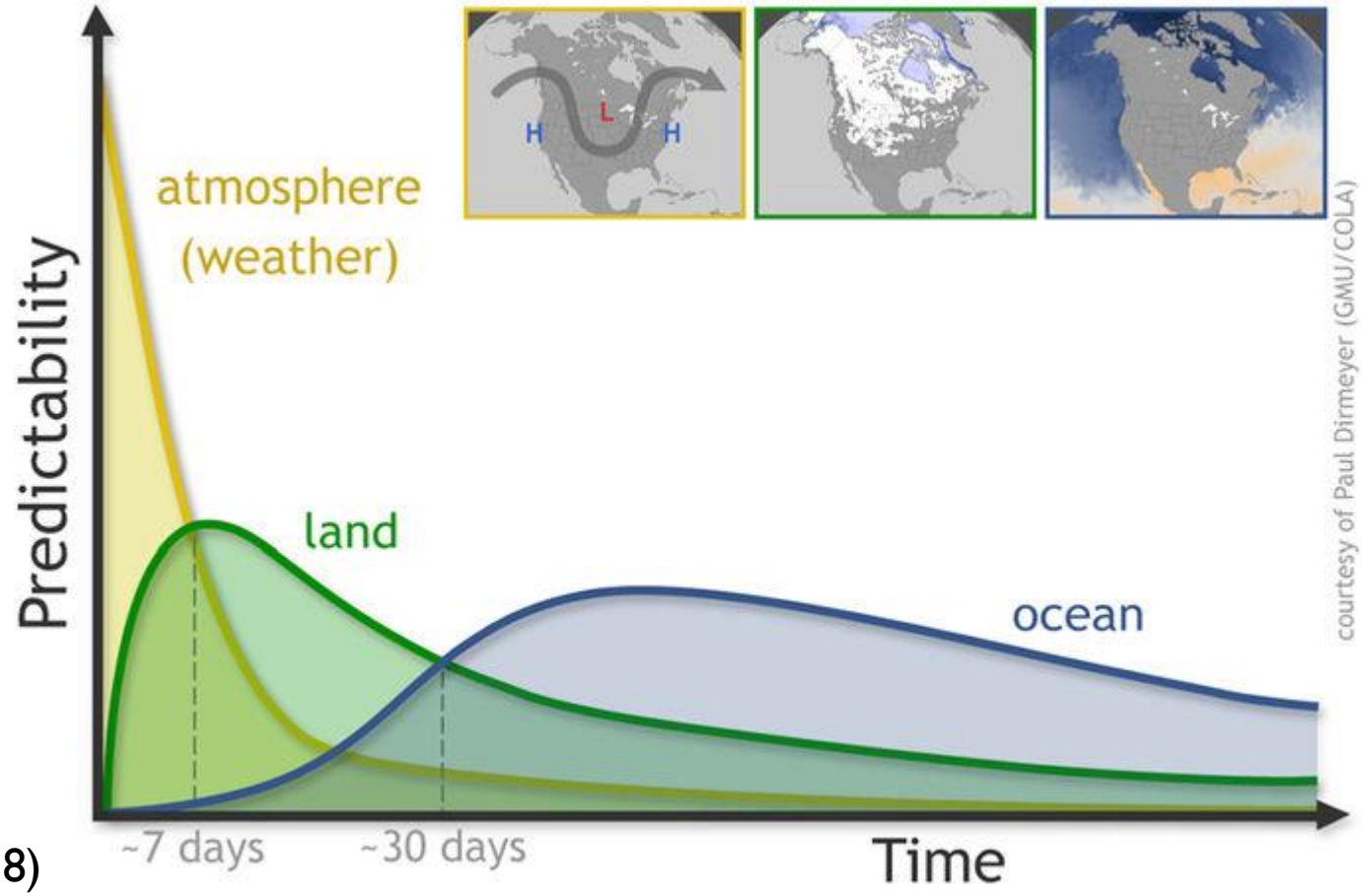
Impact of historical data rescue

- Kubota et al. (2016)
  - PJ (P-J pattern) index from 1897 to 2013 was developed by use of historical station-based pressure data in Philippine, Taiwan and Japan, and compared with reanalyses (JRA55, ERA40, 20CRv2 and NCEP/NCAR.
  - PJ-ENSO correlation was found to change in interdecadal time scale.



S2S Predictability and Land Surface

- Role of Land Surface for Predictability at different Time Scales

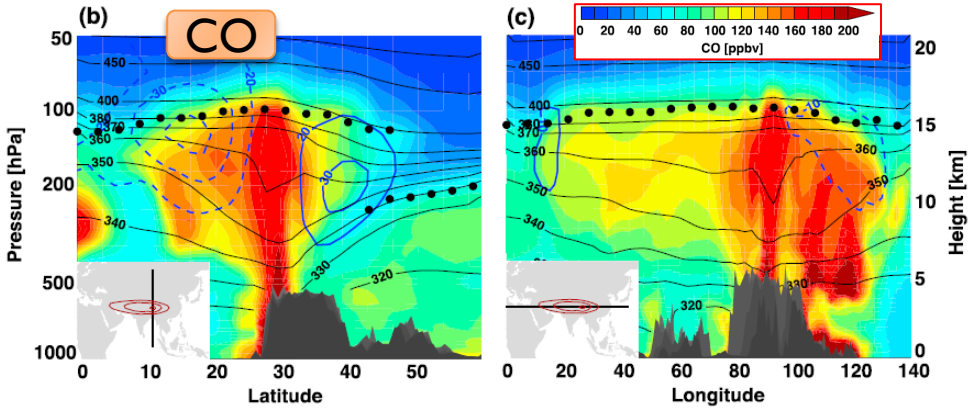


Mariotti et al (2018)

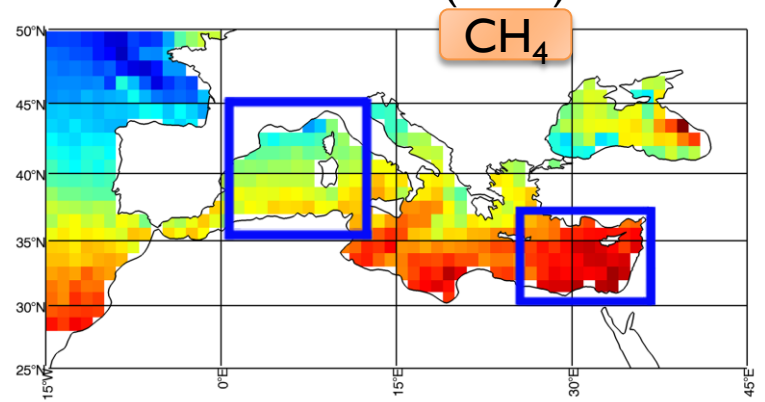
Newly Emarging Science Waves

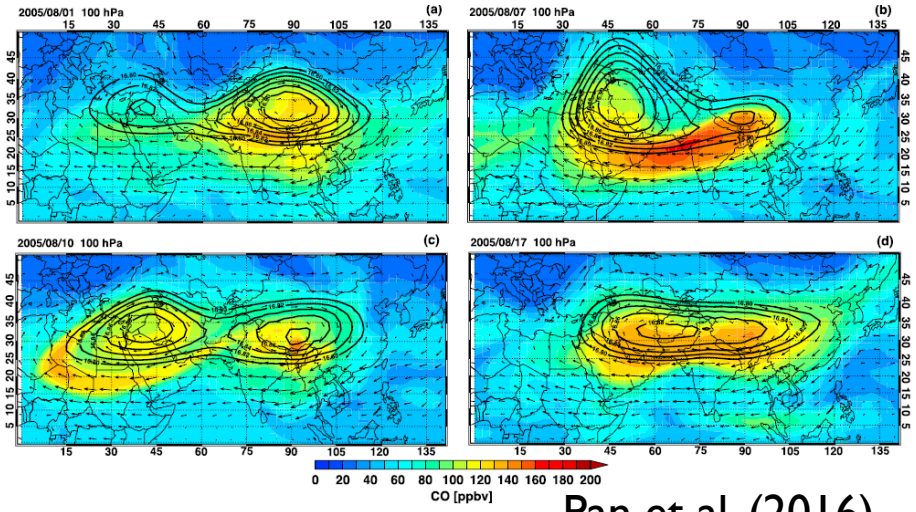
Boundary Layer -> Tropopause (UTLS)

- Investigated using tracer gas

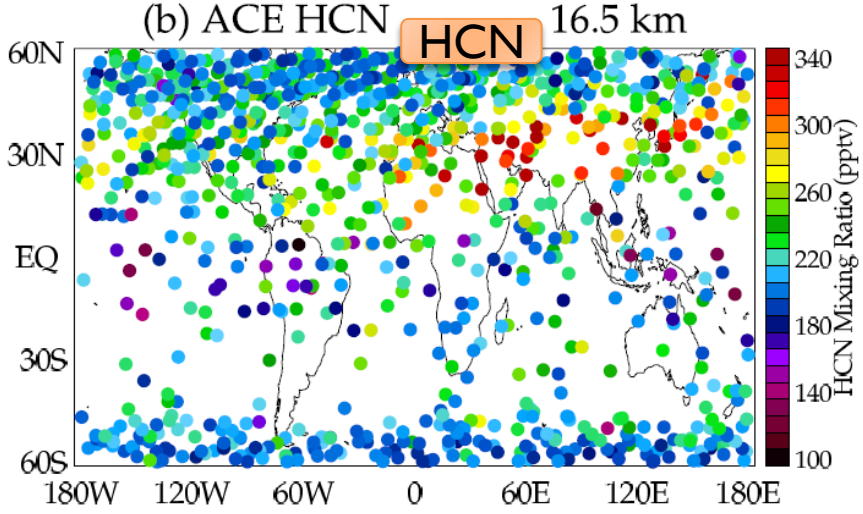


Ricaud et al. (2014)





Pan et al. (2016)



Park et al. (2008)

Science Strategies

- Impacts of Diversed Land Surface: Topography, Cryosphere, Vegetation, Land Use and Coast Lines on Diurnally Varying Precipitation Process in Multiple Time Scales from Sub-seasonal to Climate Change
- 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

Applications

- SDGs
- Disaster
- Food
- Environment
- Health

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

Science Questions

10yr

- What is the convincing climate model representations of Asian monsoon precipitation that can support policymakers to plan useful adaptation strategy for the changing climate?
- What is the possible coordinated observation initiative that advances our understanding of the Asian monsoon precipitation?
- To what extent can we use up rescued hydrometeorological data to reconstruct recent 200-year climate change?
- How can we find new scientific methods to describe, and to share information with Asian people, of the extreme weather embedded in multiple time scales in Asian monsoon hydroclimate?
- What is the role of mountain precipitation and subsequent land water process in the local and global hydrological cycles and water resources?

Q1: Climate models

- Asian Land Precipitation is controlled by
  - multiple scale meteorological disturbances interacting each other (MISO, BSISO, QBW, WD, TD, SilkRoad, IOD, ENSO, Diurnal, ...)
  - land surface impact on the atmosphere through the planetary boundary layer (Soil Moisture, Land Surface Flux, BL, Convection, UTLS process, ...)
- We will test huge amount of climate projections (many MIPS, CORDEX, S2S database, d4pdf, ...) to check if
  - they can reproduce multiple scale meteorological disturbances in their model results
  - they can express impact of land surface properly
- For example:
  - http://cola.gmu.edu/dirmeyer/

5yr

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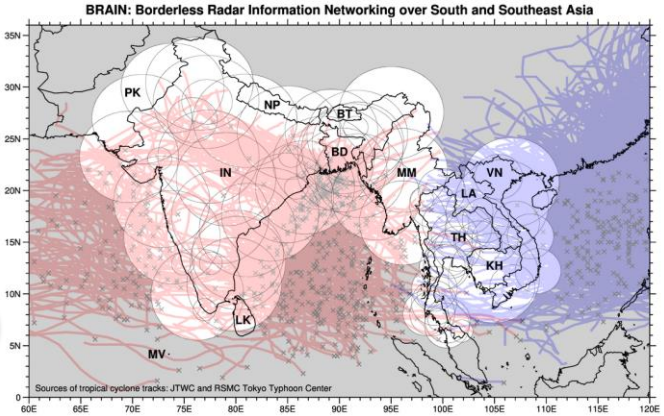
Q2: Observation Initiatives

- Focus:
  - Construction of the BRAIN (Borderless Radar Information Network) within 10-year project period



10yr

- AMY-II (2020)
  - Sharing radar data among many Asian meteorological agencies during core observation period (May-July / 60days)
  - Coordinated observations
    - Pilot areas
    - Intensive R-S, PBL tower, Soil Moisture, Wind profiler, GPS-PW network, ...

2yr

Feacibility test of radar network

- Utilized for model validation

5yr

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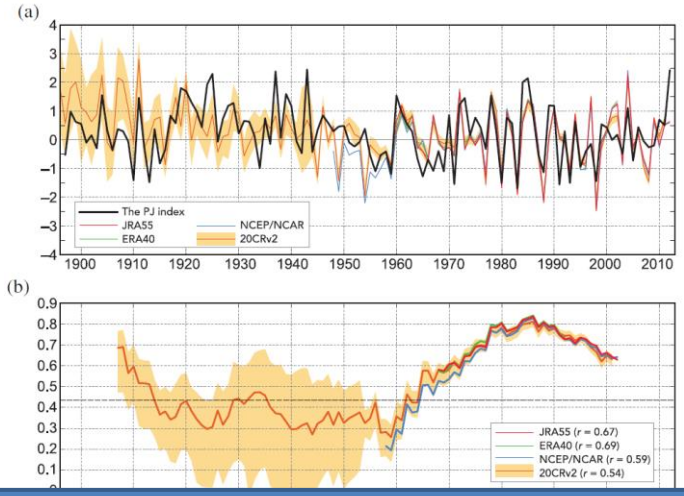
Q3: Rescued dataset

- Innovation on methodology to use up rescued data
  - knowledge of climate systems and processes
  - 20-century reanalysis projects
  - activities for further data rescue
- 200yr Climate Reconstruction

10yr



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Q4: Extremes

- Unprecedently severe hydrometeorological disasters took place in West-Japan, Kerala, Laos
  - Daily rainfall is not enough to describe the extreme
  - People's perception on extreme may have to be updated
  - We can develop new method to describe, and to share information with people, the concept of Extreme in multiple time scales

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Q5: Mountain precipitation

- Many questions:
  - How glacier increases/decreases?
  - What is distribution and variation of montain precipitation?
  - Impacts of climate change appears earlier/
  - Glacier lakes?
- Scientific interest
  - Topographic impact on convective systems
  - Impact of Tibetan Plateau on global circulation
- Expected outcomes
  - Improved precipitation griddata in Asiatic mountain area
  - Reliable estimation of net reduction of glacier

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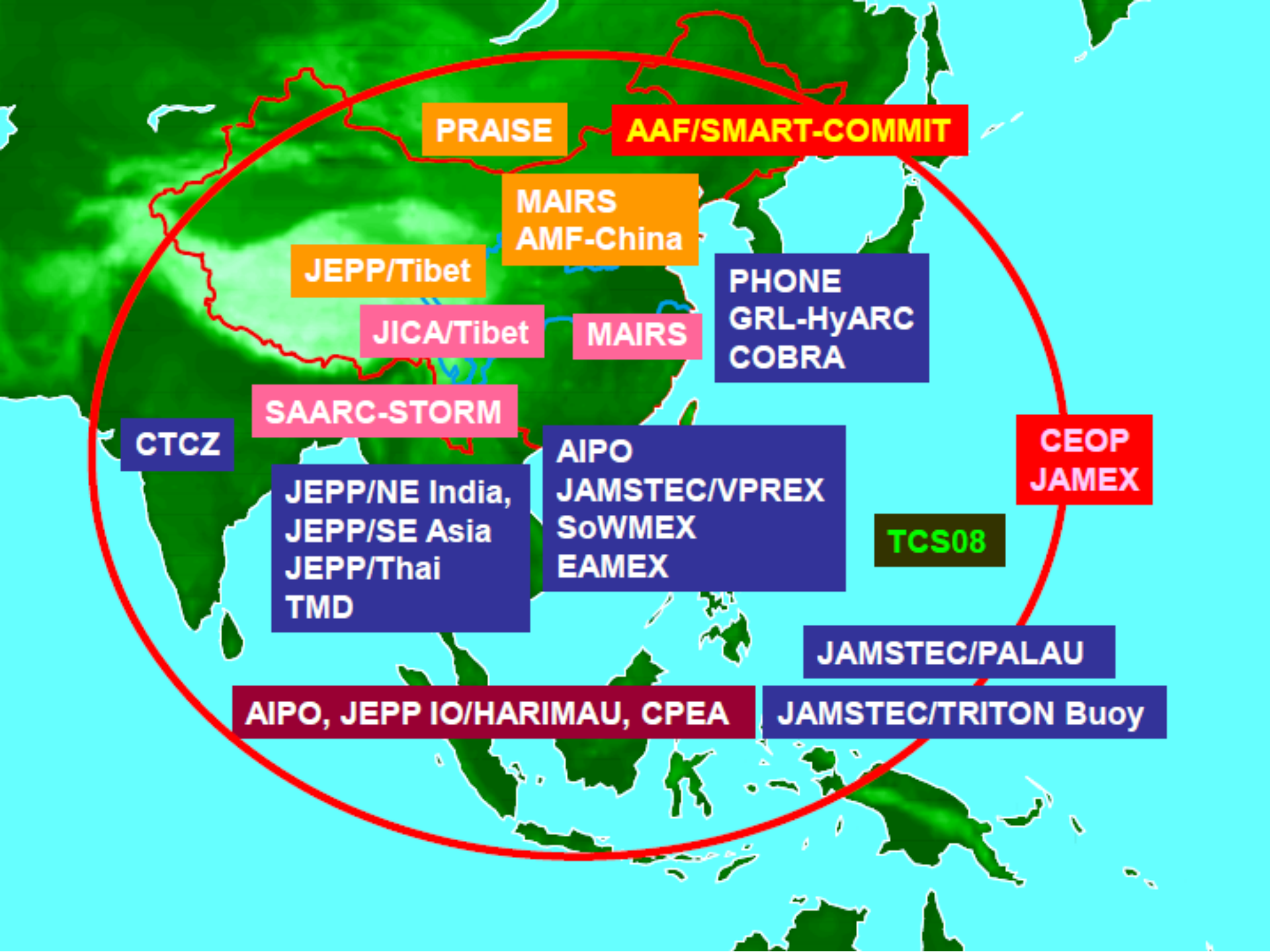
South Asian Component of Asian Mosoon Year (AMY)-II

Section 3

AMY (Asian Monsoon Years 2007-2012)

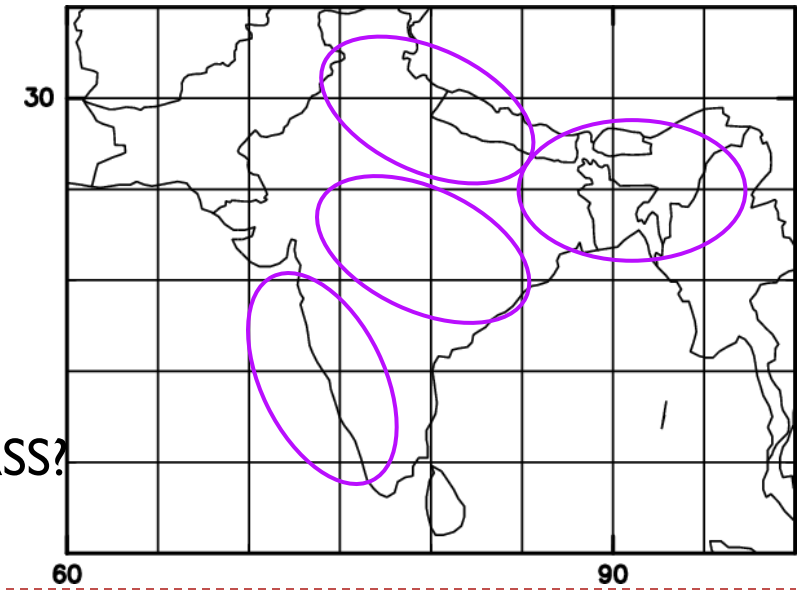
Overarching Goal:
"To improve Asian Monsoon prediction for societal benefits through improving understanding of the variability and predictability of the Asian-Australian monsoon system"

http://www.wcrp-amy.org/


PRAISE
AAF/SMART-COMMIT
MAIRS
AMF-China
JEPP/Tibet
PHONE
GRL-HyARC
COBRA
JICA/Tibet
MAIRS
SAARC-STORM
CTCZ
AIPO
JAMSTEC/VPREX
SoWMEX
EAMEX
CEOP
JAMEX
JEPP/NE India,
JEPP/SE Asia
JEPP/Thai
TMD
TCS08
JAMSTEC/PALAU
AIPO, JEPP IO/HARIMAU, CPEA
JAMSTEC/TRITON Buoy

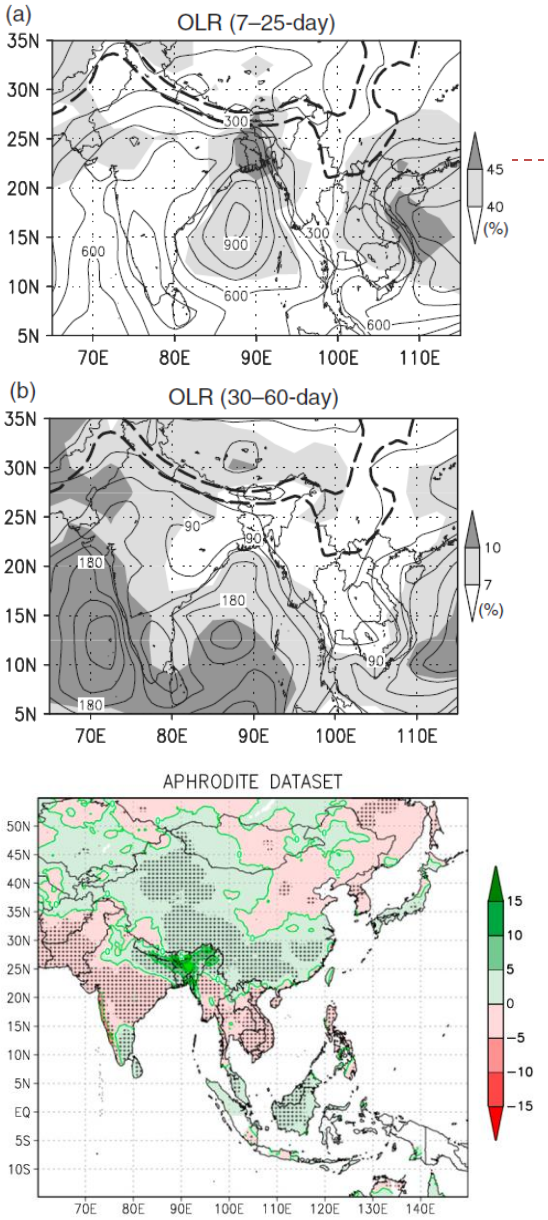
AMY-II(2020) South Asian Project

- Focusing on Four Components in the Indian Subcontinent
  - Northeast, Northwest, Central India, Western Ghats
  - Different roles during seasonal transition and ISV?
    - Transition from pre-monsoon to monsoon and in A/B cycle
      - Different process in Northwest and Northeast and relathionship
      - Role in monsoon onset of Northeast severe local storms in premonsoon
      - Role of central India for onset
    - International Collaboration
      - Northeast-> Japan group
      - Northwest
      - Central India-> IITM?
      - Western Ghats
    - Modelling? / RADAR? / INCOMPASS?



Active/Break cycle

- Different frequency range
  - Fujinami et al. (2011)
  - Northeast/OLR, North/U: QBW
  - 30-60day variability in other area
- Correlation in A/B cycle
  - Murata et al. (2017)
  - Correlation with NE Rain
    - Negative in Central India and Western Ghats
    - Positive? in Northwestern India
- Interactive framework
  - LS-BL-Convection-UTLS



What can we observe in AMY-II?

- RADAR data exchange for 60day period
  - Intensive continuous observation in Bangladesh?
- Field Campaign
  - Soil moisture observation (Remote sensing + ground truth)
  - Intensified R-S observations
  - Special instruments
    - wind profiler, micro rain radar, disdrometers
  - GPS-Precipitable Water measurement network
  - Surface Flux observation network
  - ...
- Modelling and remote sensing
- Possible outcomes by 2023?

Message

- We are launching new hydroclimatological research initiative on Asian monsoon under GEWEX/GHP. It will be approved in GEWEX/SSG in Feb-Mar 2019.
- We tentatively concluded five major Scientific Questions: Climate Models, Coordinate Observations, Data Rescue, Extremes, and Mountain Precipitation
- AMY-II is planned in 2020. We will promote people to conduct AMY-II jointly.
- For South Asian monsoon area, we proposing a framework based on the concept of interaction of four major regional hydroclimate systems: Northeast, Northwest, Central India, and Western Ghats.

ありがとうございます！
Arigato- Gozaimasu!

Thank you very much!

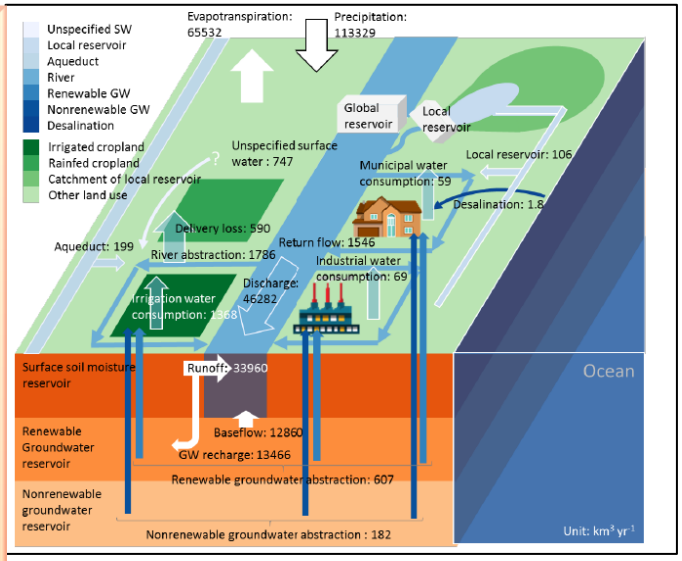
1 Precipitation Estimation

2 Process studies

3 Understanding and Prediction S2S<=

Validation and improvement of hydrological model which incorporates human water withdrawal.

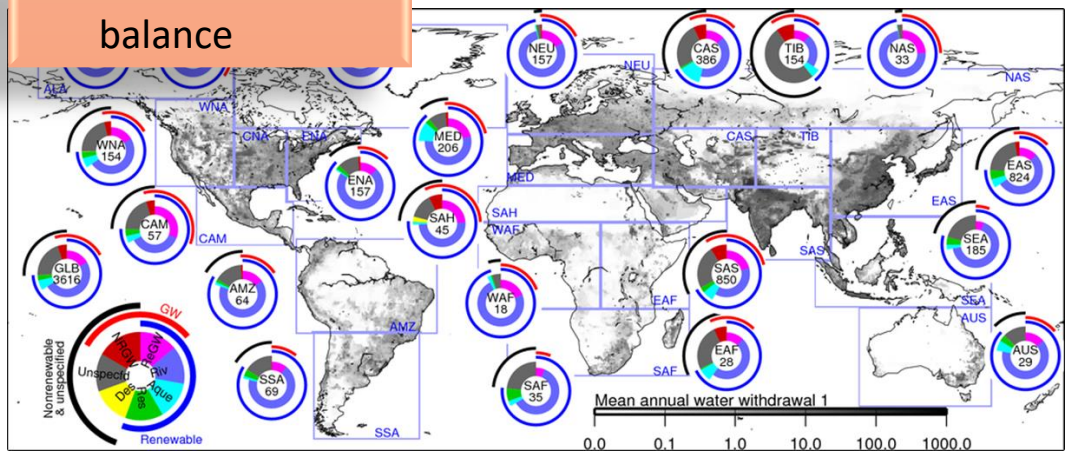
1. Groundwater recharge
2. Groundwater abstraction
3. Aqueduct water transfer
4. Local reservoirs
5. Seawater desalination
6. Return flow and delivery loss
7. Surface water balance



(Hanasaki et al. 2017, HESSD)

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

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



Water sources by region (Hanasaki et al., 2017)

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

5 Integrated Observation

6 What is Reliable Climate Projection

- What can we do for that!?