JAXA Joint PI Meeting
(GCOM-W & AMSR3)

2022-01-17 (Mon)
Online

Prediction of precipitation and streamflow by land-atmosphere data assimilation

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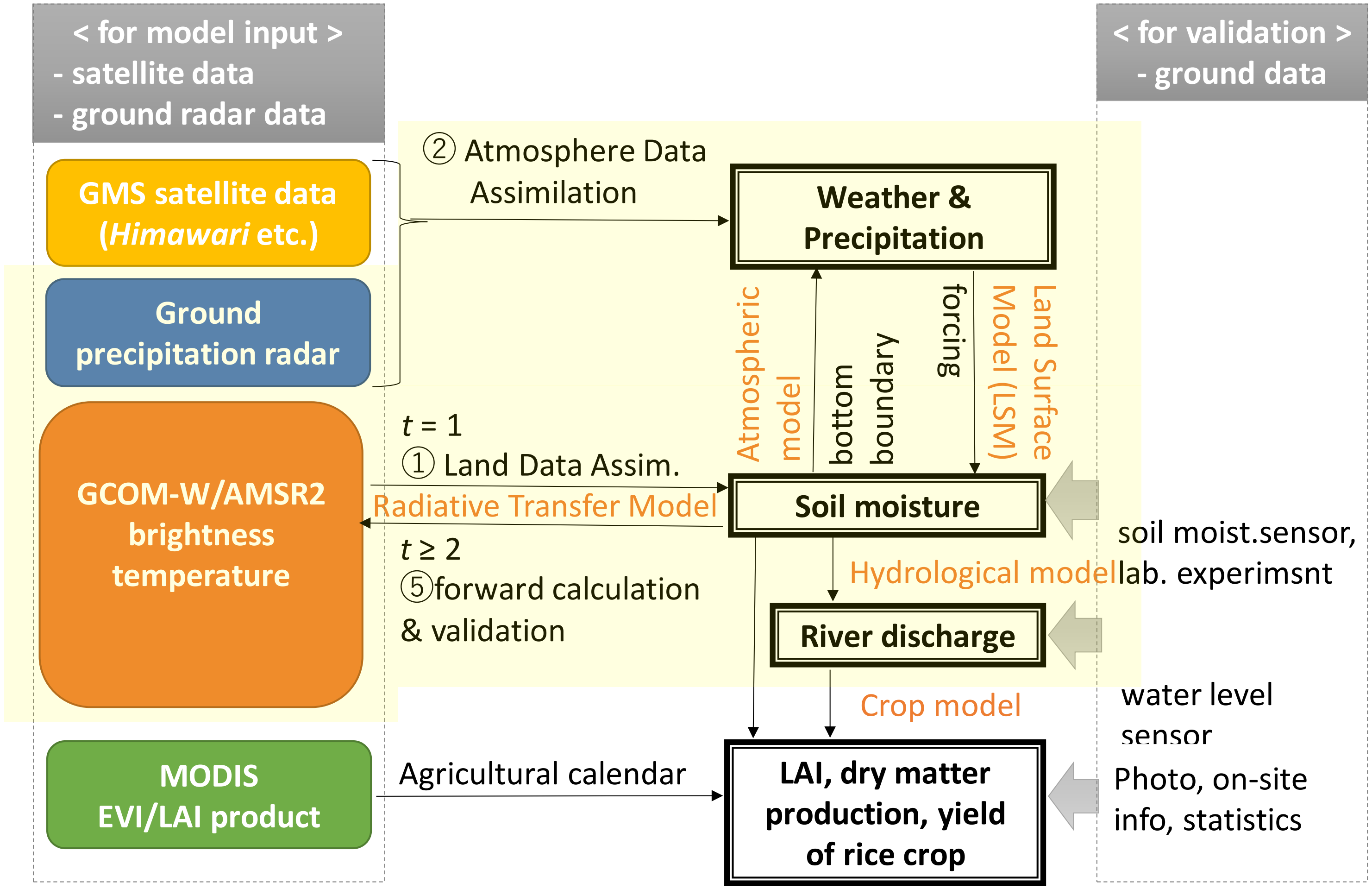
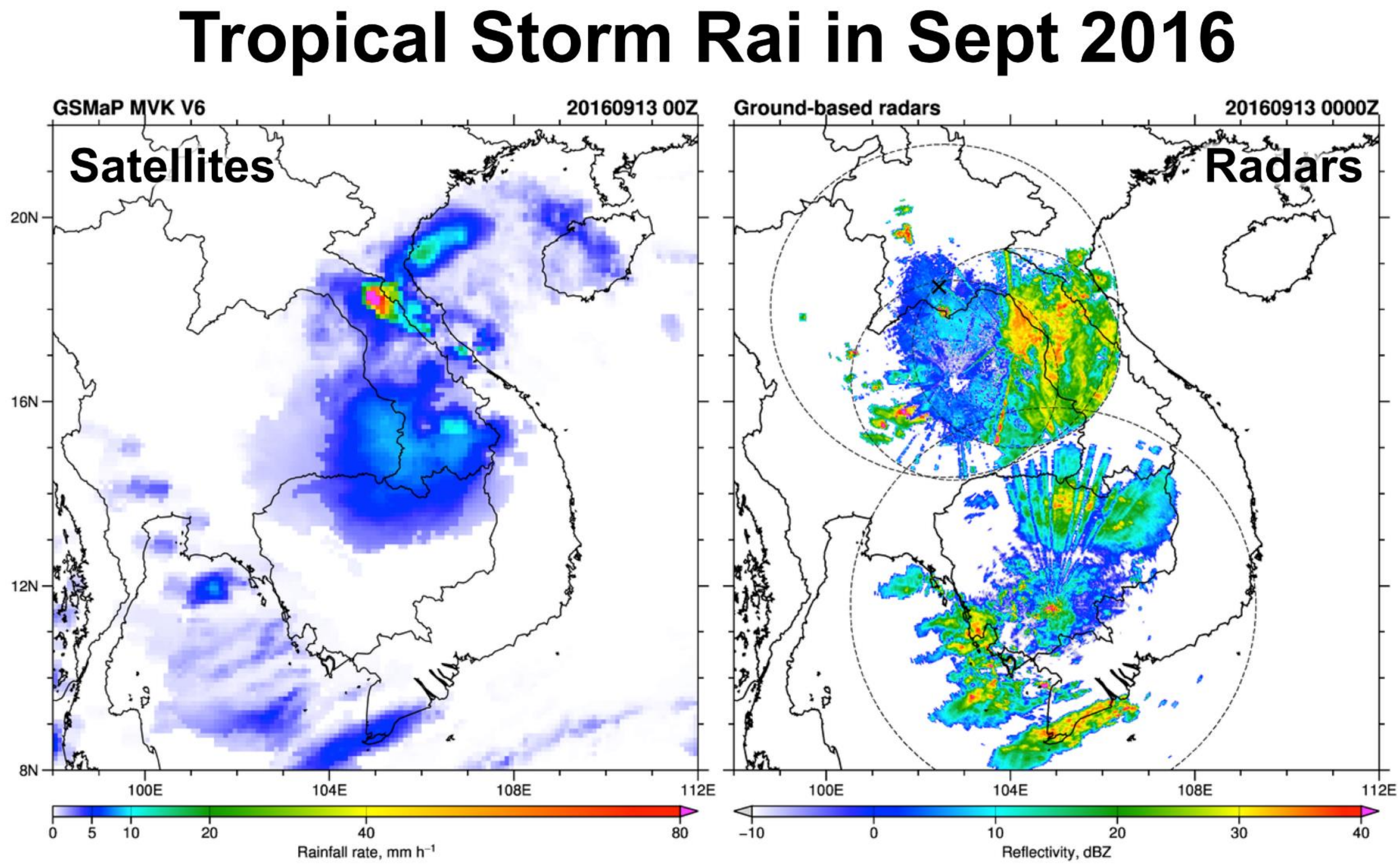
Objectives

- Applying Data Assimilation of the AMSR2 observations to Numerical Weather Prediction and hydrological models to improve the prediction accuracy of precipitation and streamflow



Ground Precipitation Radar data analysis



- for atmospheric data assimilation
- to be used with WRF and hydrological model

Contents

1. **Validation of the AMSR2/SMC product**
   - Evaluation of the observational error for data assimilation
   - Cambodia, Australia, Spain

     ← different land surface condition
2. **Improvements of land-surface RTM**
   - Focusing on the dielectric model of wet soil
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   - By a mesoscale atmospheric model (WRF) and data assimilation
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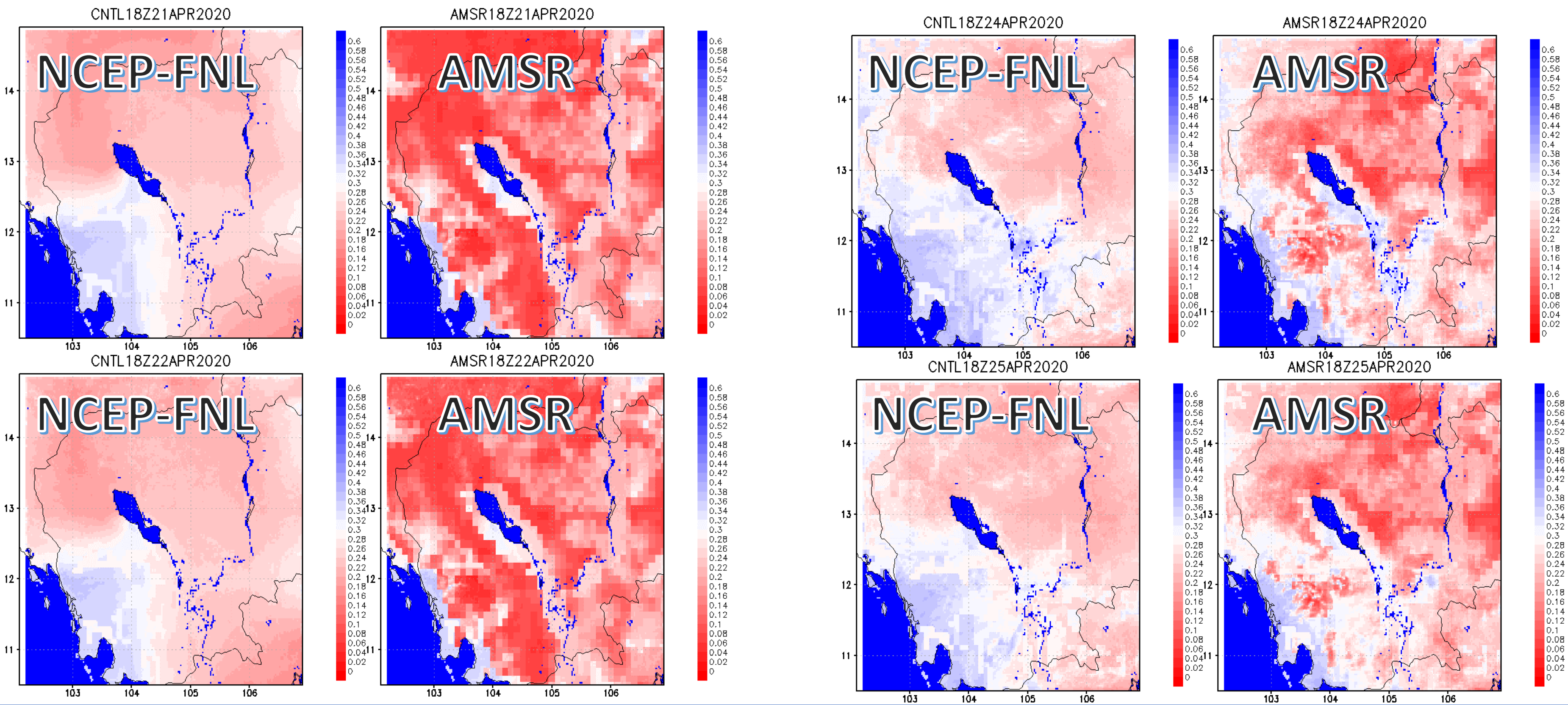
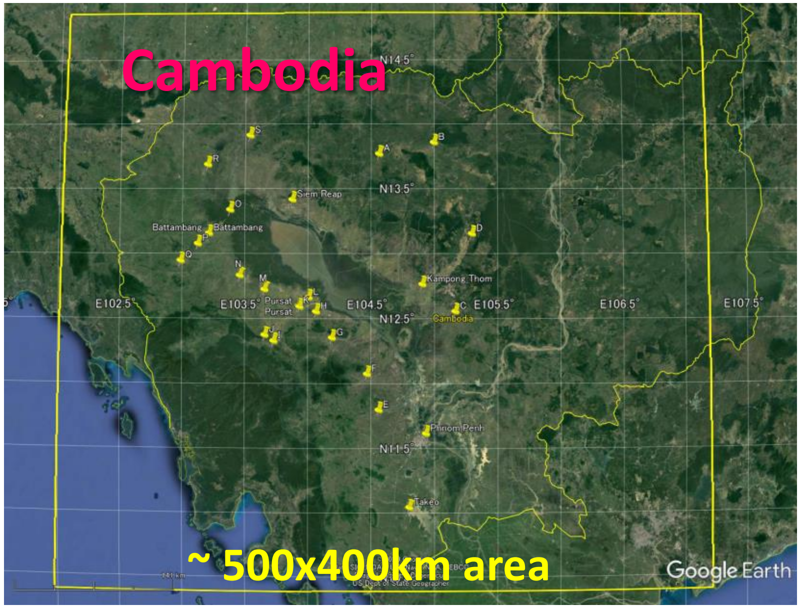
   - By a basin hydrological model and data assimilation

Model & observation errors

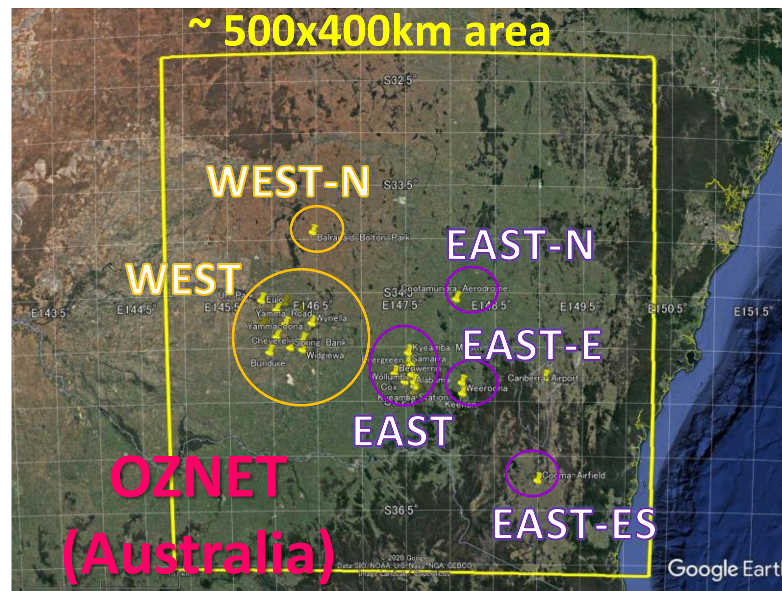
- *How to evaluate the errors of the GCM input (NCEP-FNL), AMSR observation, and the WRF model?*
  - Research Point: Quantification of each error characteristics to be used for land data assimilation



Evaluation of the observation error



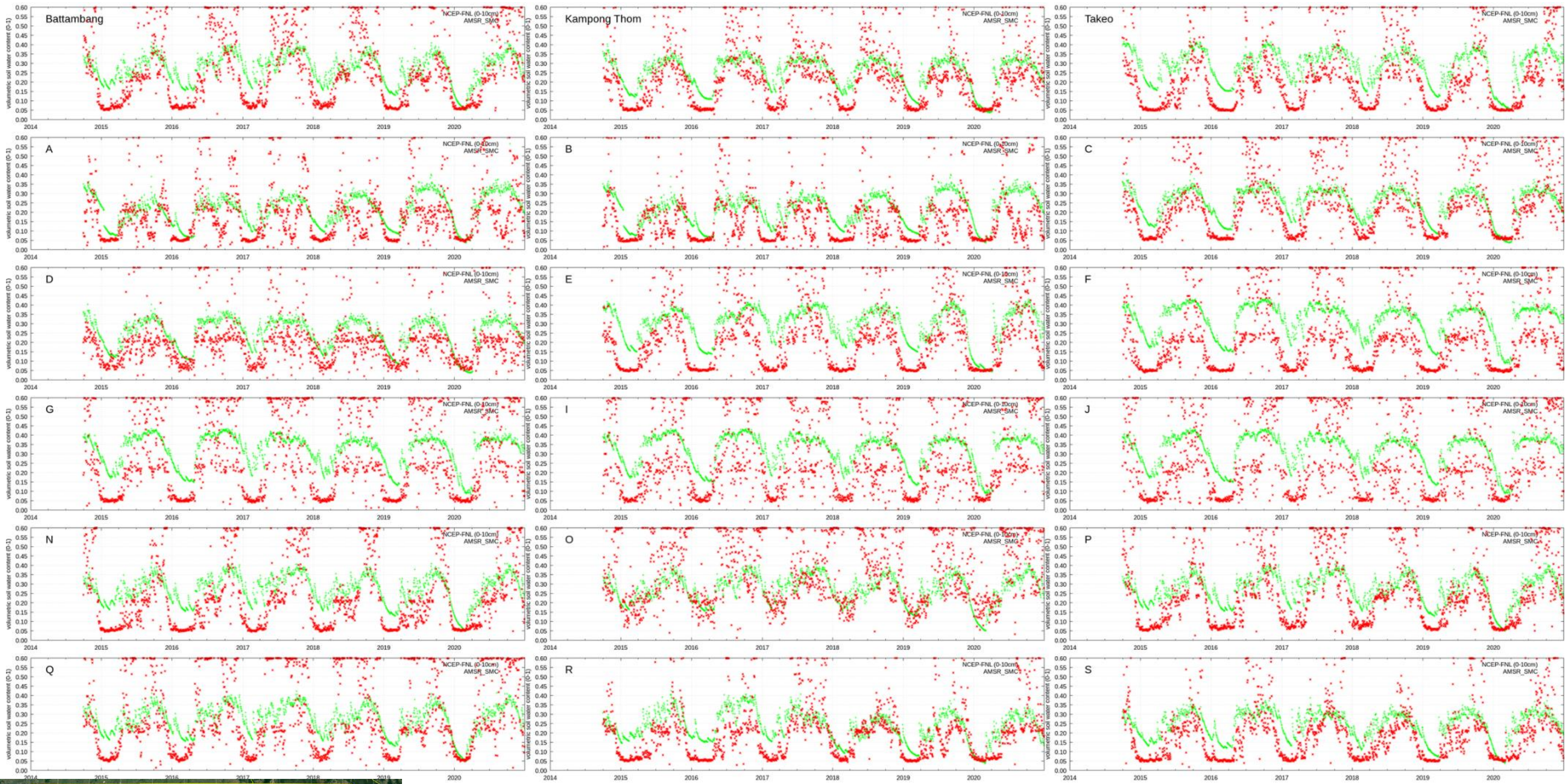
- Cambodia
  - Humid, densely vegetated
  - field survey were conducted by ourselves in the past years
  - Past observation data are under analysis
- Spain & Australia
  - Semi-dry, sparse/short veg.
  - In-situ data were obtained from the ISMN website https://ismn.geo.tuwien.ac.at/

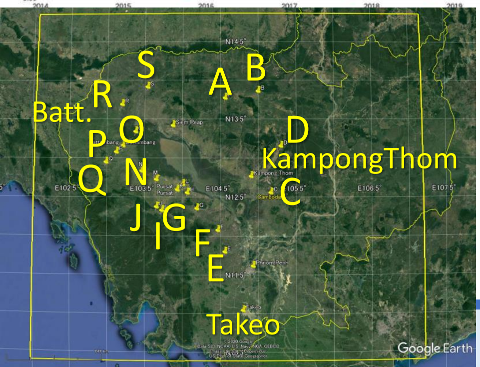


@Cambodia

2014-2020
18 stations

NCEP-FNL
AMSR-SMC





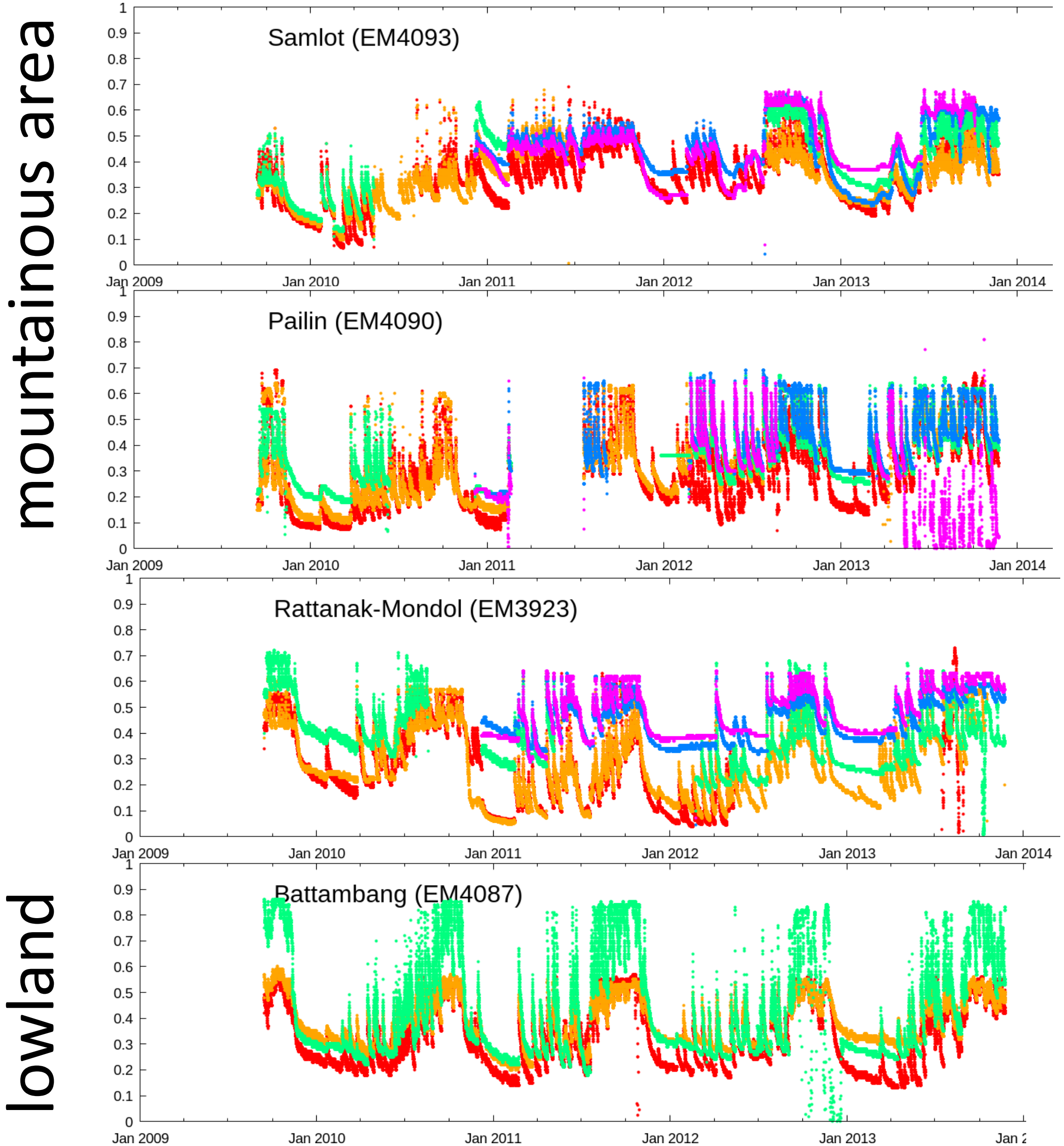
@Cambodia

NCEP-FNL
AMSR-SMC

Soil Moist. Histogram
@Cambodia

- Histogram
  - X: soil moisture
  - Y: frequency
- Only Descending Data (02:00LT) is used for AMSR2
- At each station, only the days on which AMSR-SMC data are available in 2014-2020 were used for plotting the histogram

In-situ obs. @Cambodia



- In-situ obs. from 2010-2013
- measurements at 2, 5, 10, 20, and 30cm depth

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RTM for land surface

Observed brightness temperature $T_{B_{obs}}$ by a satellite sensor (GCOM-W/AMSR2)

λ: frequency, γ: incident angle

Simulated brightness temperature $T_{B_{obs}}$ by a forward model in LDAS-UT *[Fujii 2005; Yang et al., 2007]*

$$T_{B_{est}} = \underbrace{T_g\left(1-\Gamma\right)e^{-\tau}}_{\text{soil}} + \underbrace{T_c(1-a)(1-e^{-\tau})(1+\Gamma e^{-\tau})}_{\text{vegetation}}$$

soil

vegetation

$\tau = f(\gamma, \lambda, LAI, \text{vegetation type})$

$a = f(\lambda)$

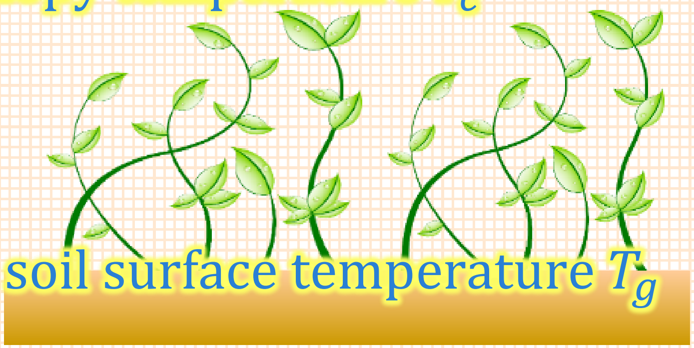
$\Gamma = f(\gamma, \varepsilon, \text{surface roughess})$

$\varepsilon = f(\lambda, \theta, \text{porosity}, \%\text{sand}, \%\text{clay})$

ε: dielectric constant of wet soil

Dobson model → Mironov model?

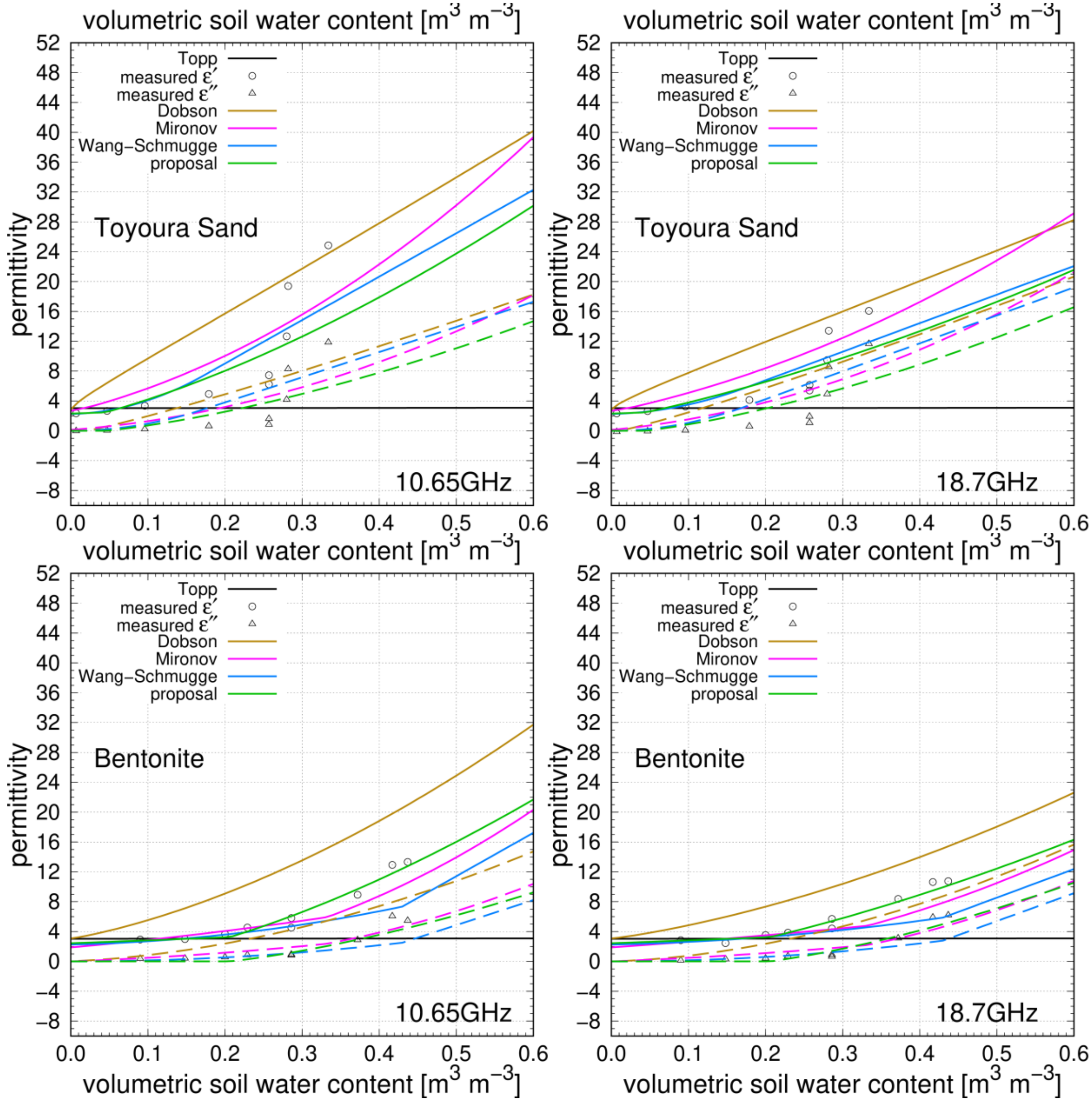
canopy temperature T_c



Radiative Transfer Model (RTM) of the land surface

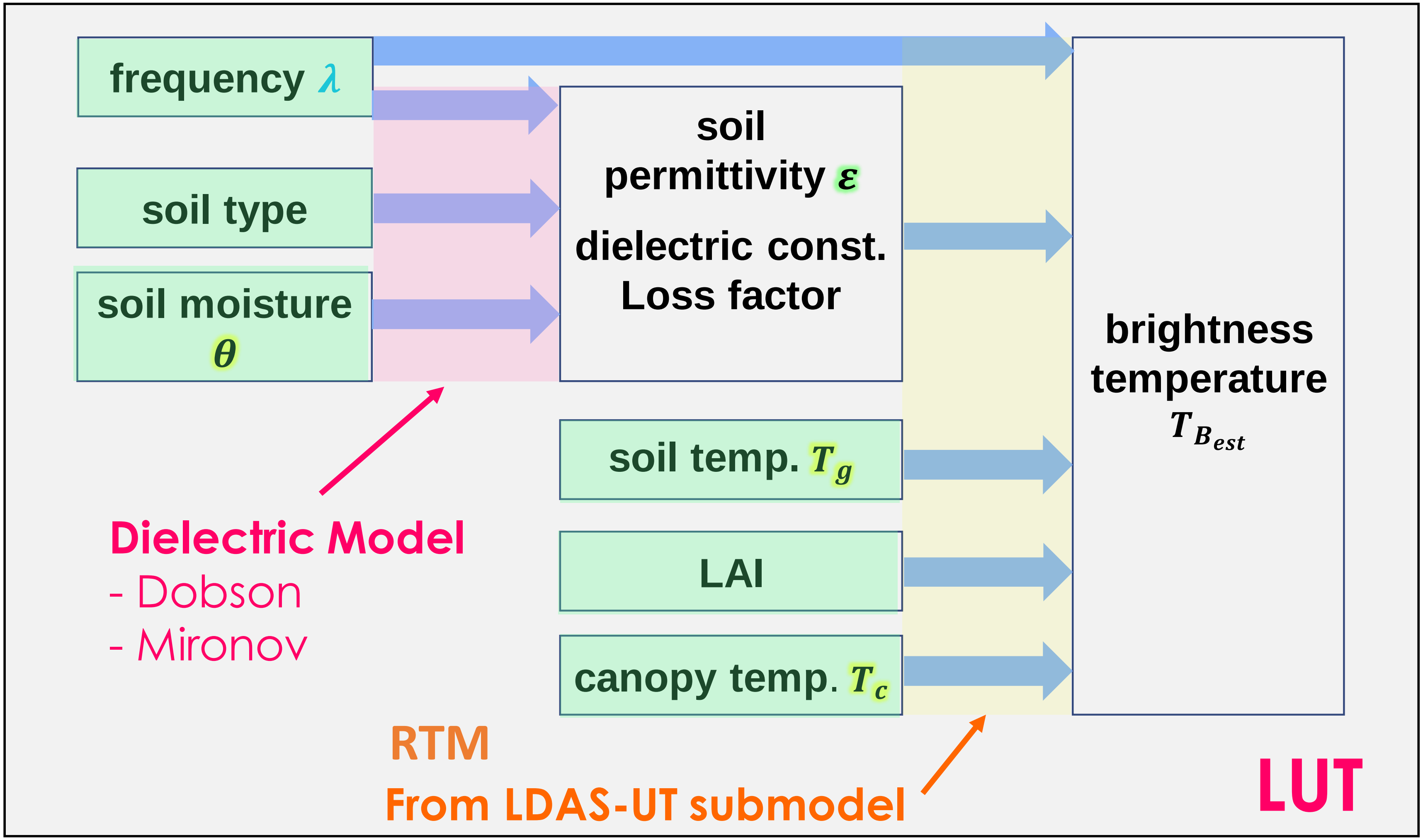
Dielectric property of wet soils

- Validation by laboratory experiments.
- Dielectric model
  - Dobson’s model
  - Mironov’s model



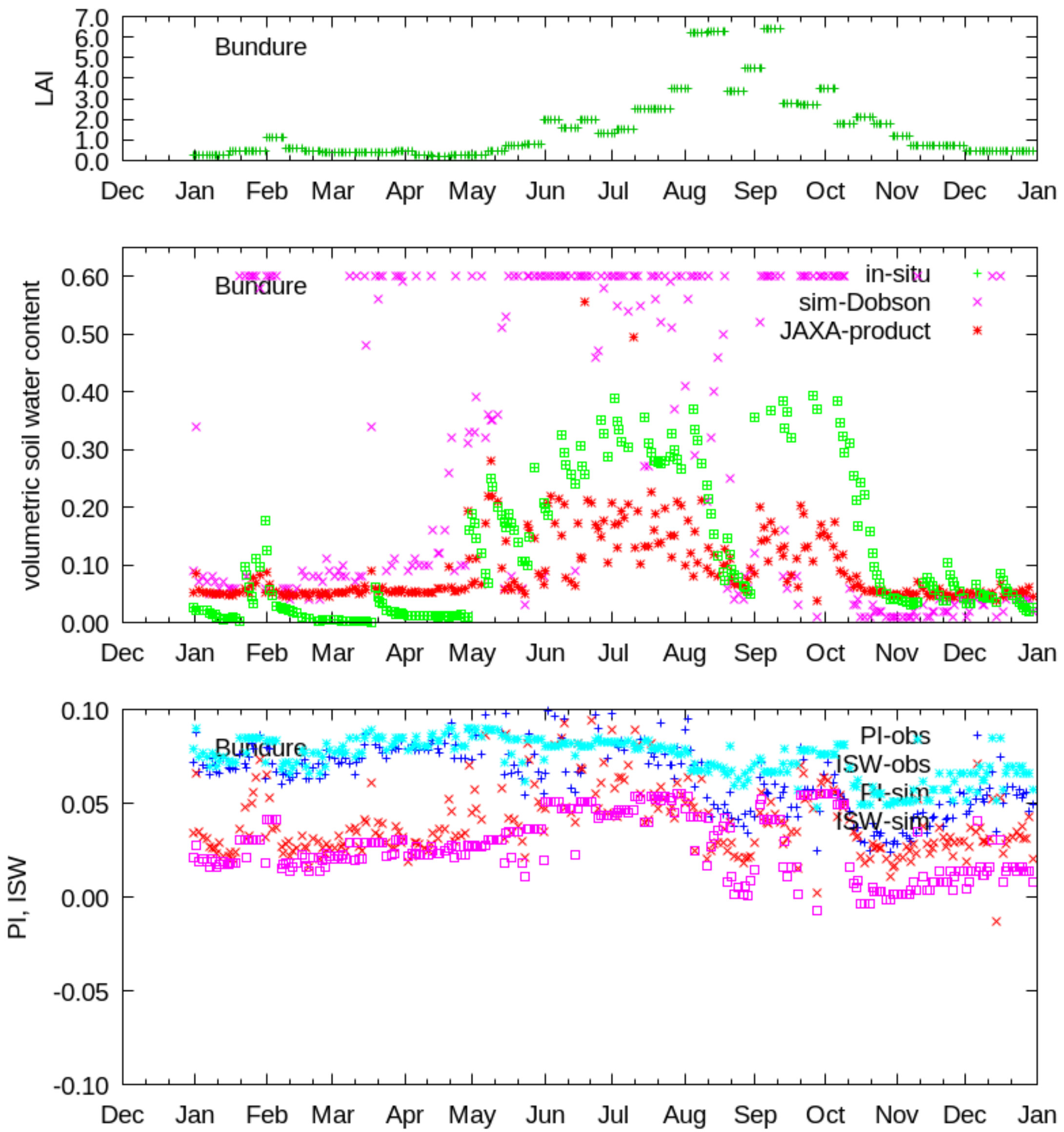
Flowchart

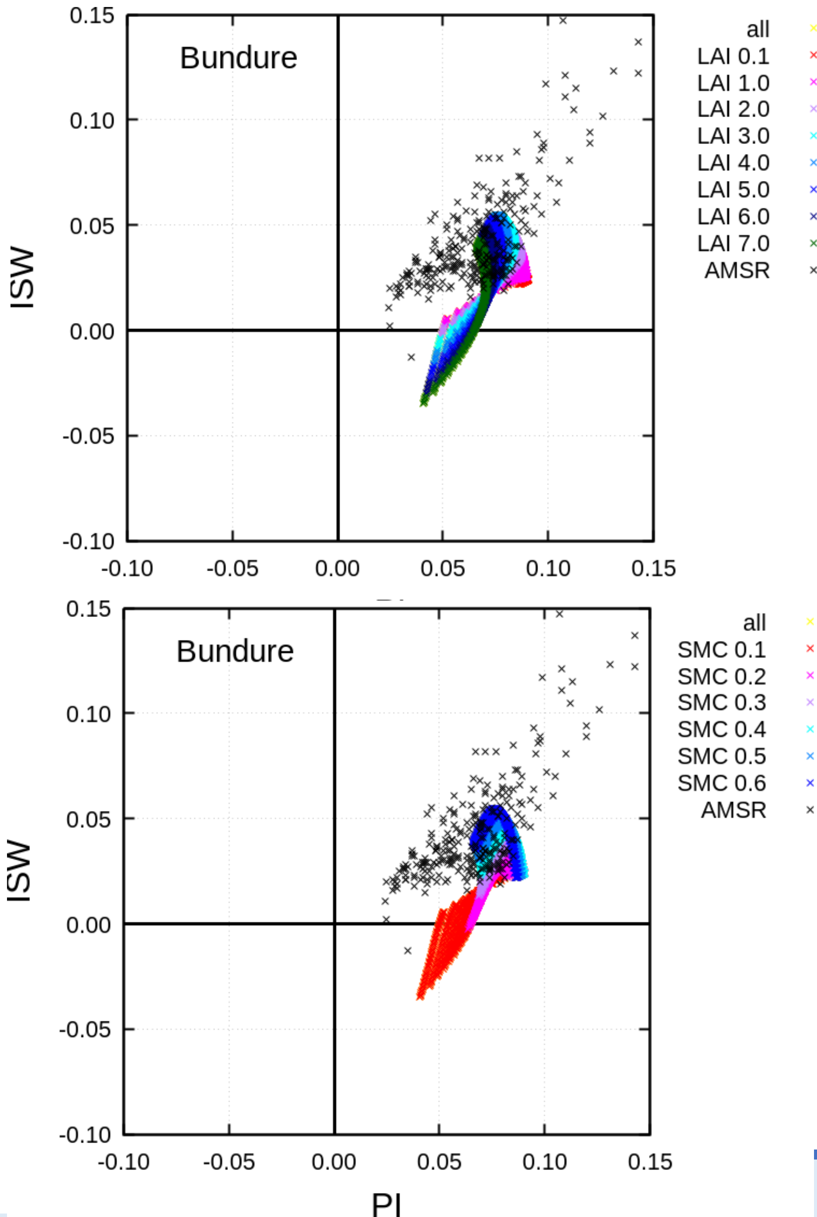
- Create the Look-Up Tables (LUTs) for various conditions using the RTM forward model with Dobson and Mironov model, respectively



II. RTM improvement for land surface

@Australia





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Error statistics for model & observation

[Example 1]

Precipitation diff. [mm] in 5 days in April 2020 in Cambodia

GCM
Soil Moisture

→ *frequent pre-monsoon rainfalls*

Data Assimilation by 1-D Var

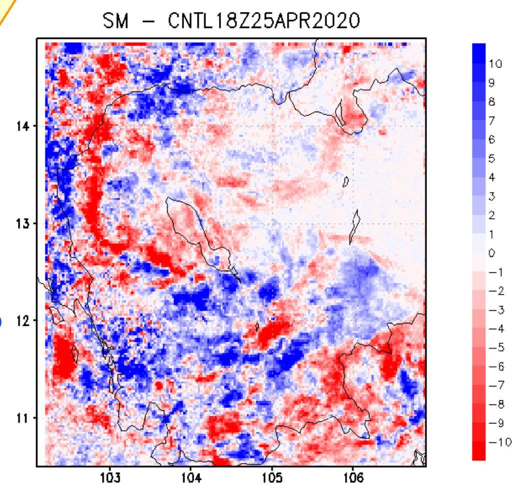
Initial condition for WRF

Precipitation by WRF

Background error?

AMSR product on Soil moisture

Observation error?



Background error of the WRF model

- Estimated using the U.S. National Meteorological Center (NMC) method [Parrish and Derber (1992), Lin et al. (2017)]

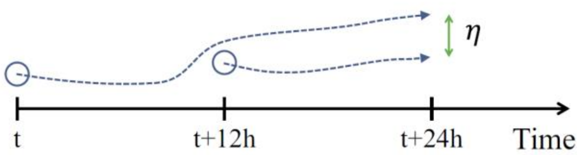
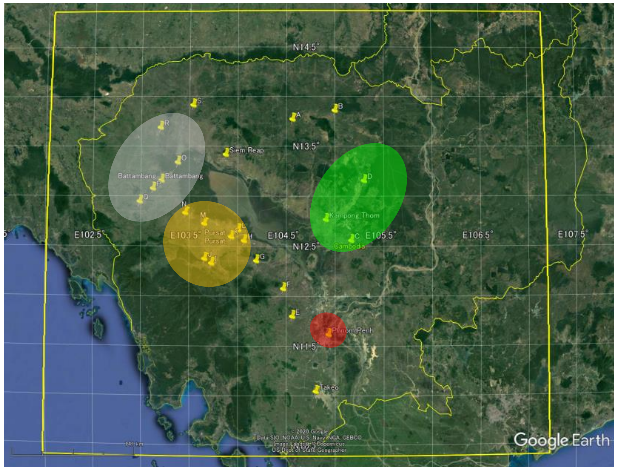
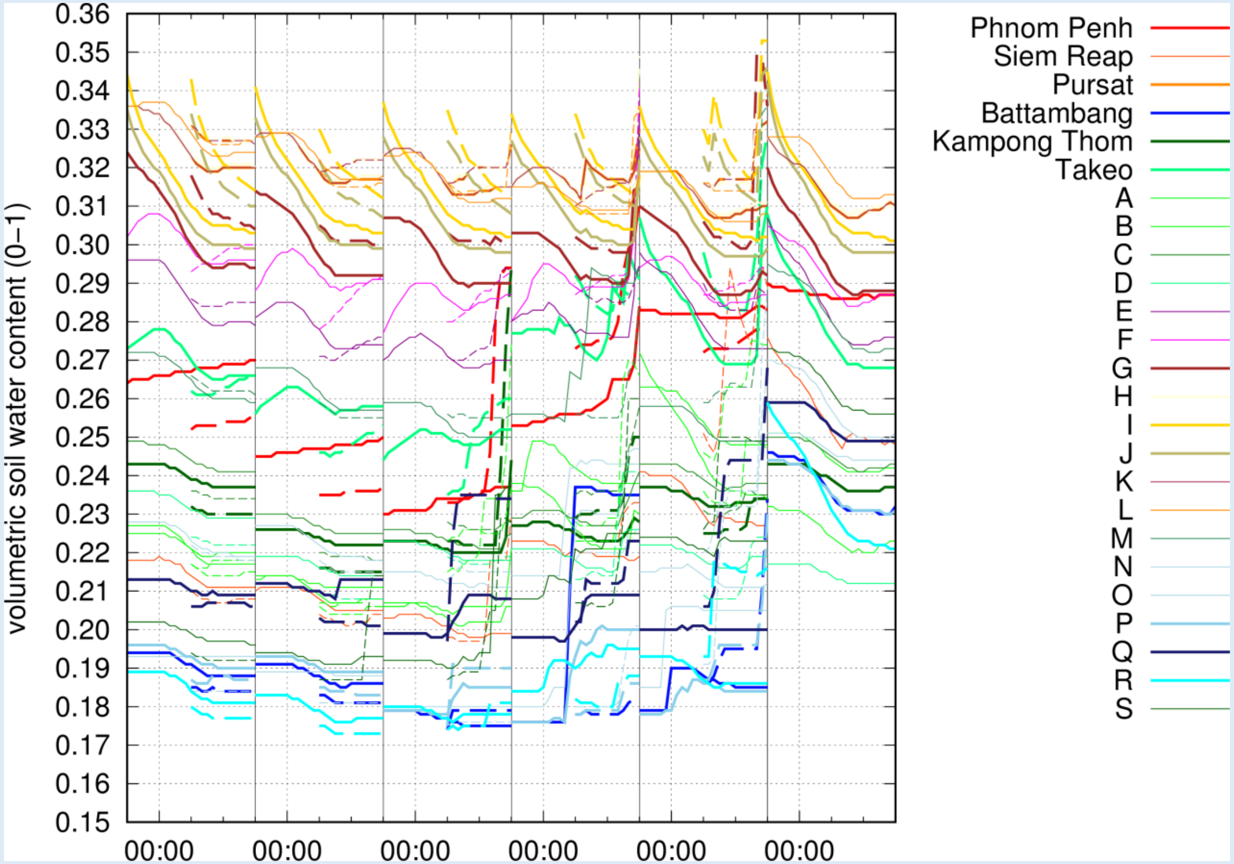


Figure 1. Schematic diagram of the National Meteorological Center (NMC) method showing the forecast error (η) between forecasts with 12 and 24 h leading times.



Case study for 6 days in April 2020 over Cambodia
12-h forecast (solid line) & 24-h forecast (dashed line)



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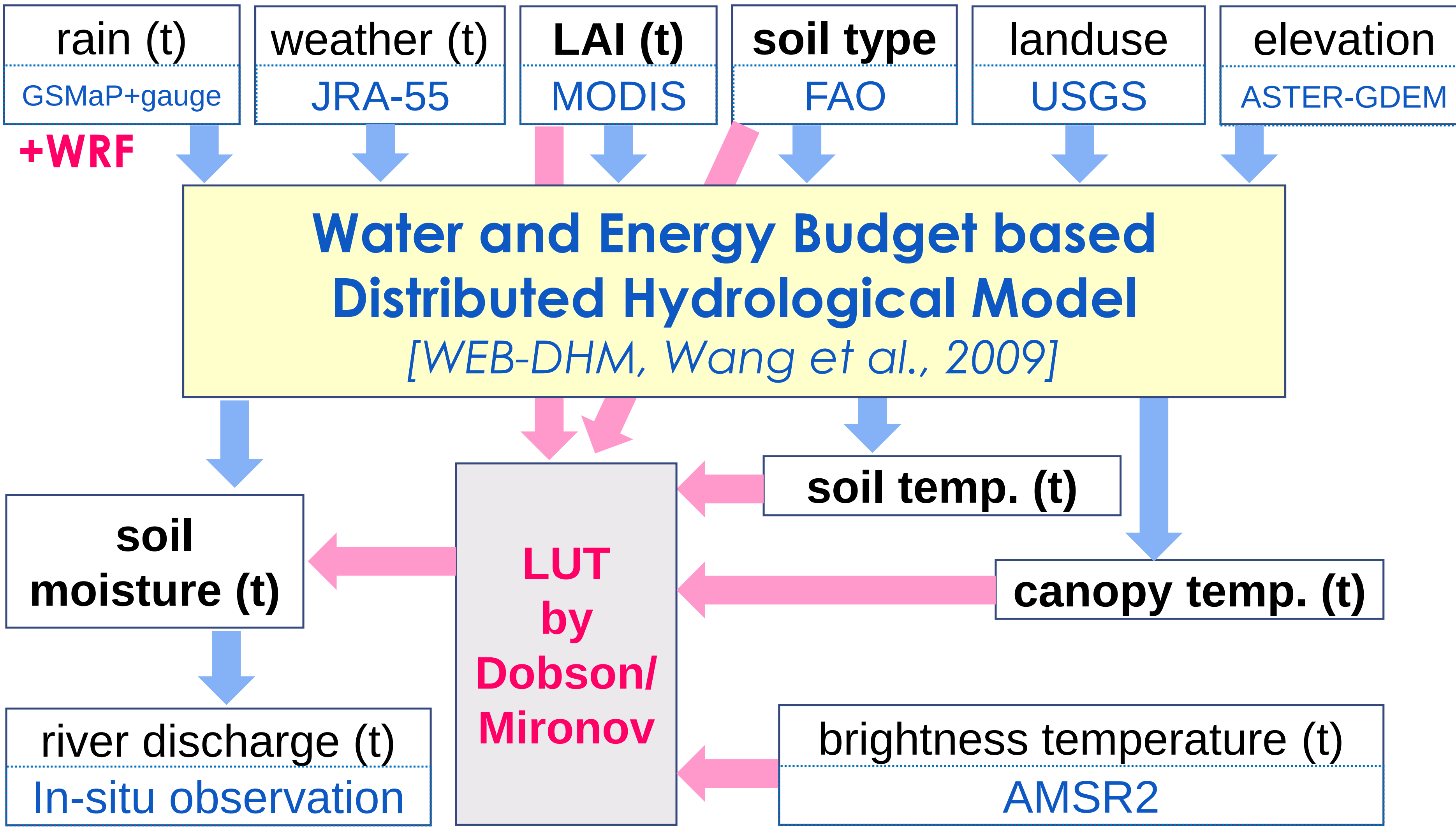

rain (t)
GSMaP+gauge
+WRF
weather (t)
JRA-55
LAI (t)
MODIS
soil type
FAO
landuse
USGS
elevation
ASTER-GDEM
Water and Energy Budget based
Distributed Hydrological Model
[WEB-DHM, Wang et al., 2009]
soil moisture (t)
LUT by Dobson/ Mironov
soil temp. (t)
canopy temp. (t)
river discharge (t)
In-situ observation
brightness temperature (t)
AMSR2

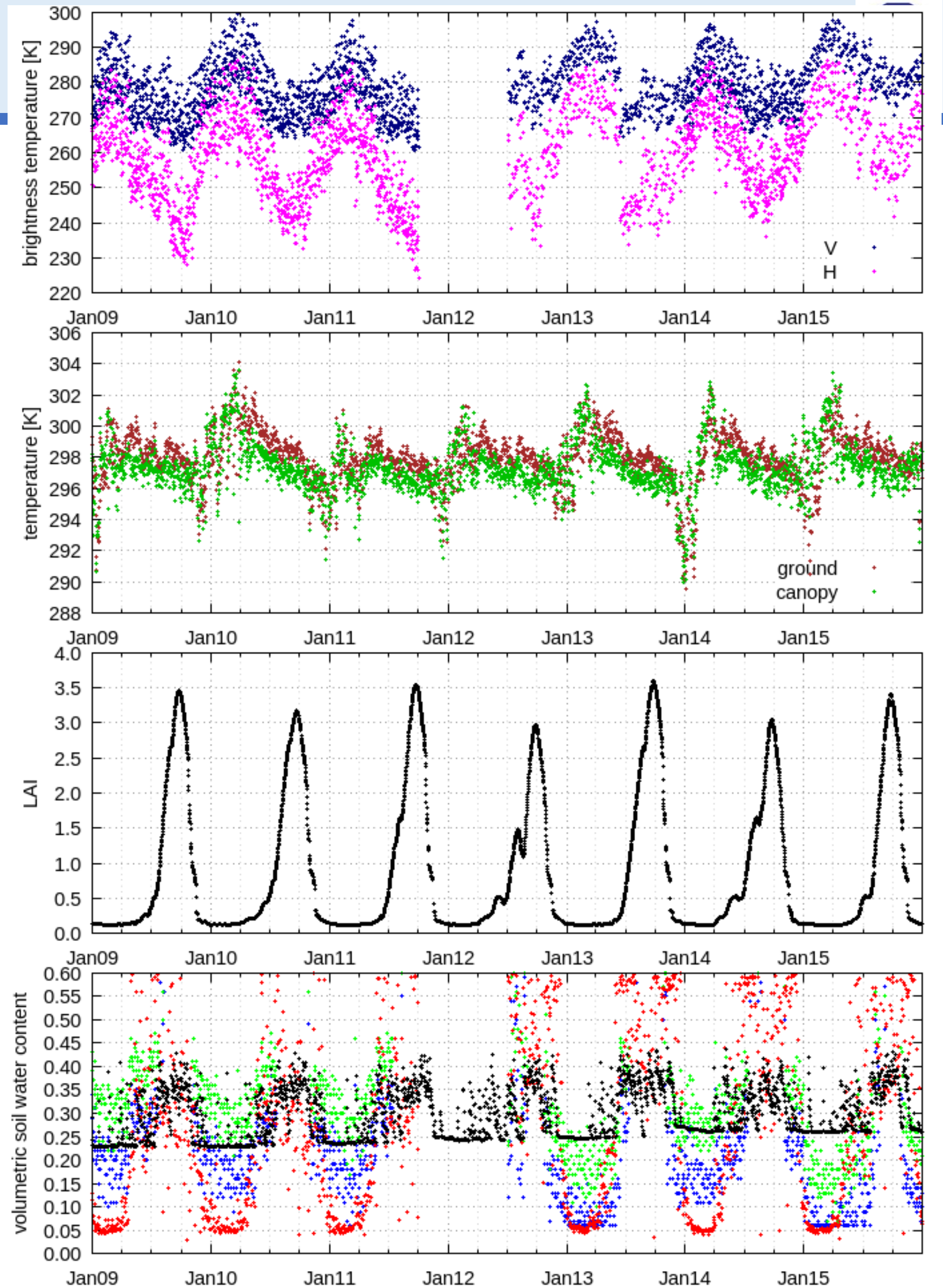
Result

(a) TB_H, TB_V
← obs. by GCOM/AMSR2
→ Used as inputs to RTM

(b) Physical temperature (soil & canopy)
← Calculated by a basin hydrological model （WEB-DHM+SIMRIW）
→ Used as inputs to RTM

(c) LAI
← Calculated by WEB-DHM+SIMRIW & Obs. By MODIS
→ Used as inputs to RTM

(d) Soil moisture estimates
- Calculated by WEB-DHM+SIMRIW
- JAXA product (with Dobson model)
- Calculated with RTM (Dobson model)
- Calculated with RTM (Mironov model)



Summary

- The method for the effective data assimilation of the AMSR2 observations to WRF for improving precipitation and streamflow predictability was examined through
  1. A study on the evaluation of the AMSR2 observation error (= AMSR-SMC product error), background error of the WRF model, and the error of the global reanalysis data (e.g., NCEP-FNL)
     - Quantifying the error statistics information to be used for land DA in WRF
     - They have regionality and seasonality?
       - Cambodia (land-surface heterogeneity & dense vegetation)

       ⇔ ISMN stations at Australia & Spain
     - Case study in Cambodia in the pre-monsoon season
       - A large difference is recognized in the southwestern mountainous region
       - Much wetter in NCEP-FNL than in AMSR
       - → Effects on precipitation & streamflow prediction
  2. A study to improve the land-surface RTM which relates soil moisture and the AMSR2 brightness temperature
     - especially focusing on the wet-soil dielectric model: Dobson/Mironov model
     - aiming to improve the AMSR-SMC product accuracy
     - Replacement of the Mironov's model was suggested to be effective