Climatic Change ‘related’ modeling

Food Security package: Utilize satellite-derived products

Atsushi Higuchi (CEReS, Chiba University, Japan)

Collaborated with: Kenji Tanaka (DPRI, Kyoto University/CEReS CU), Hideaki Takenaka (JAXA EORC/CEReS CU), Shunji Kotsuki (AICS, Riken), Taro Shinoda, Masaya Kato (ISEE, Nagoya University), Koichi Hasegawa (CTI Inc.), Koki Honma (Tohoku University), Misako Kachi, Takuji Kuboda (JAXA/EORC), Yasushi Kajiwara (CEReS, CU)

CHIBA UNIVERSITY

GEOSS-AP Symposium: WG5 Agriculture and Food Security, Jan 12 Tokyo, Japan

CEReS released Himawari-8 gridded product with free of charge!

Himawari-8 Standard data (FD)

CEReS H-8 gridded product

並列計算による
超高速精密
幾何補正処理

40 sec. all data can process
for precise geo-correction

Release note: http://www.cr.chiba-u.jp/databases/GEO/H8_9/FD/

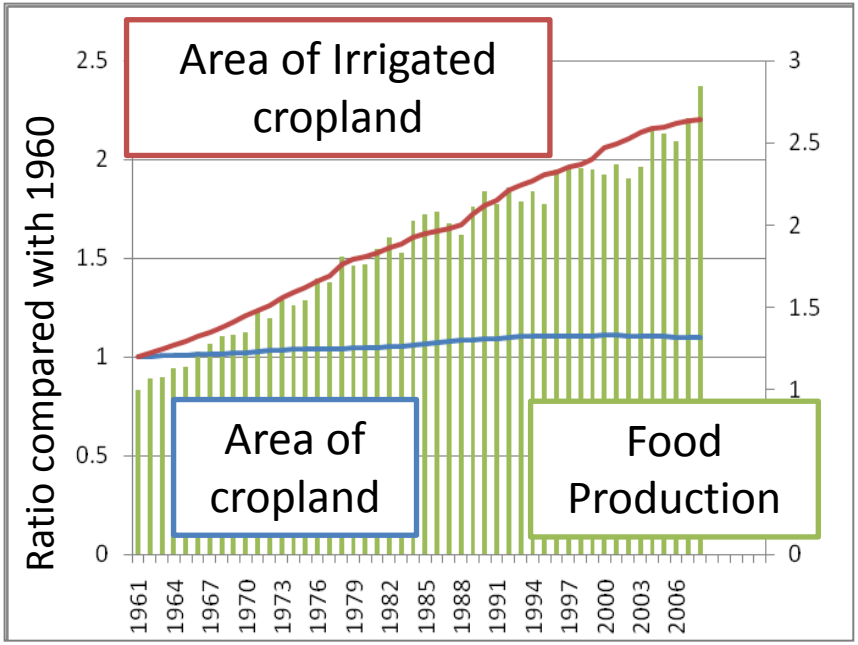
ALL BAND (16 Bands) equivalent to same spatial resolution (0.02, 0.01, 0.005 deg.)

Background

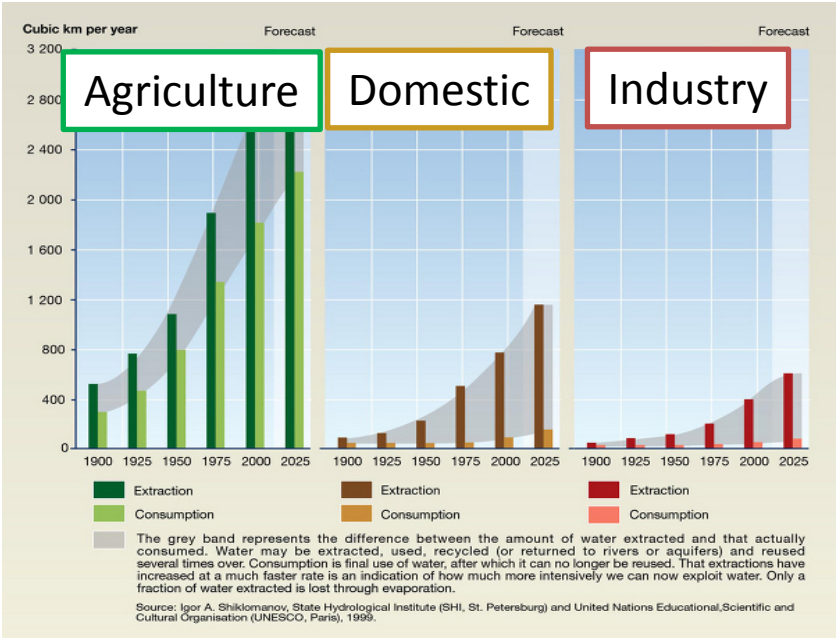
- Rapid growth of world population
  - → major increase in *food* and *water* demand.
- Key word: Irrigation
  - Good : Producing much food (about 2.5 times)
  - Bad : Requiring much water

irrigation

Food Production of The World (FAOSTAT)

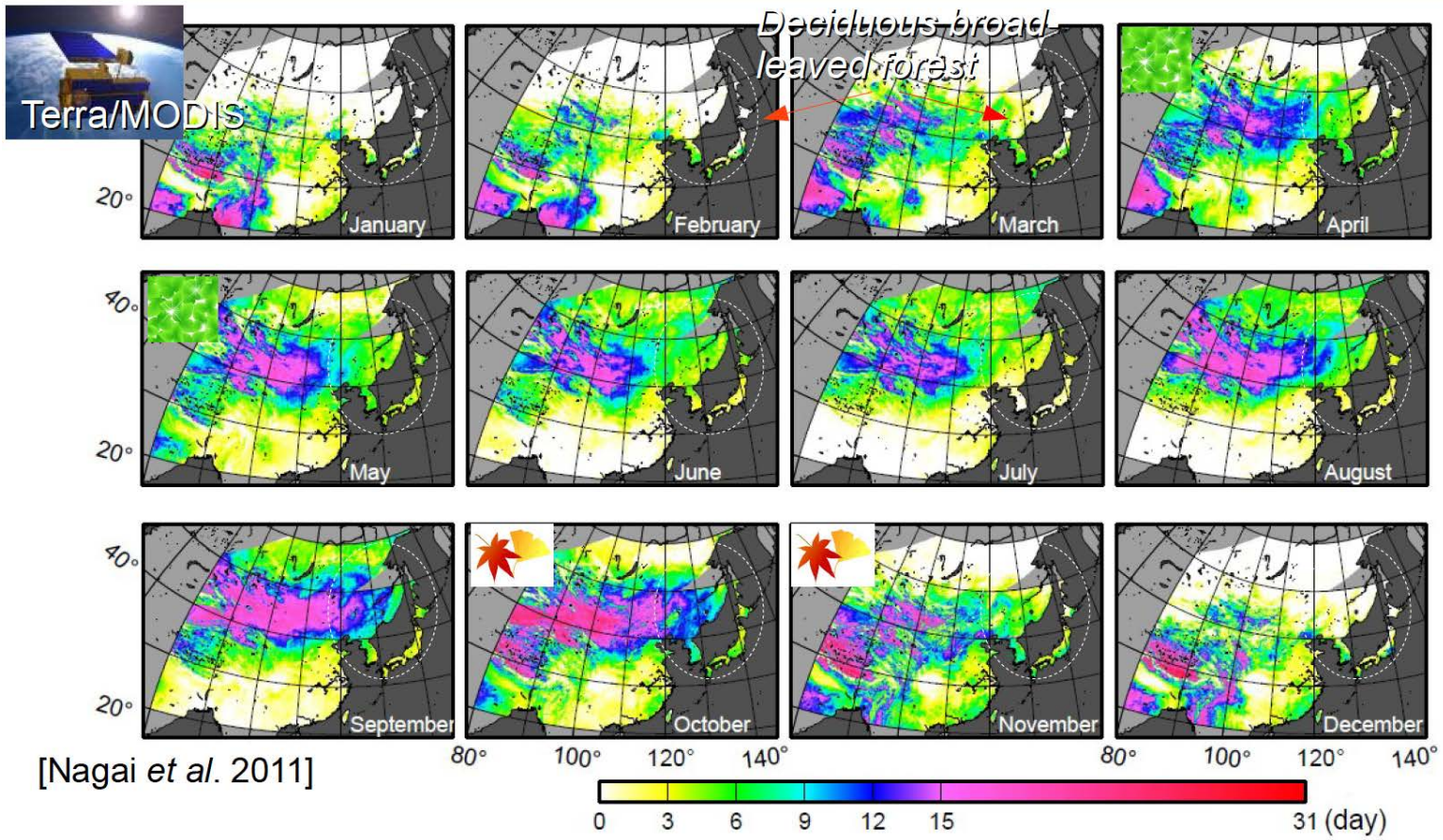


World Water Use (Shiklomanov, 2000)



Why we use numerical modeling?

Number of observational days in high-quality NDVI in East Asia:



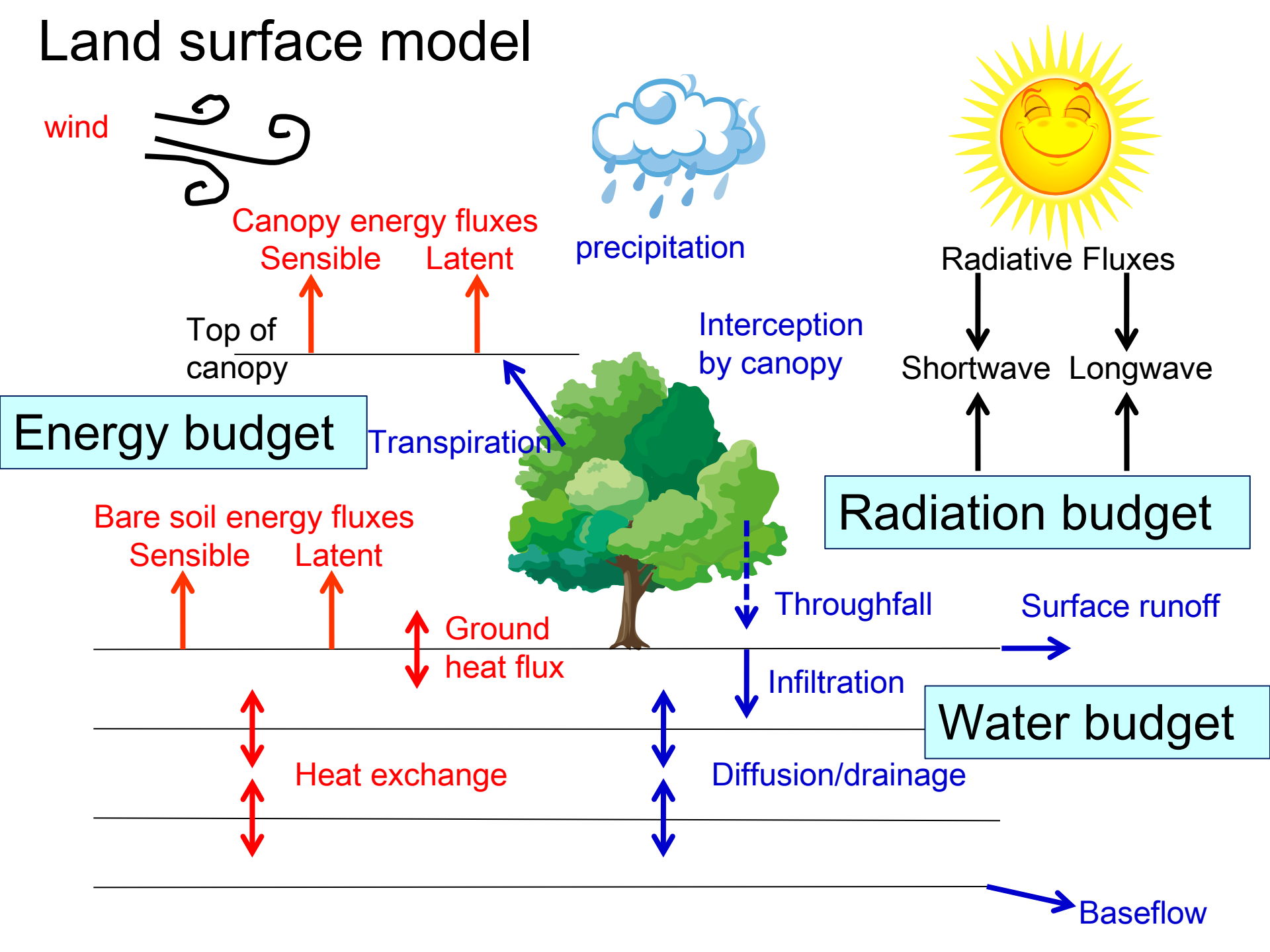
[Nagai *et al*. 2011]

During the leaf-expansion and leaf-fall periods,

number of observational days is **about 3–7** for each month.

Slide by Dr. Nagai @JAMSTEC, Japan

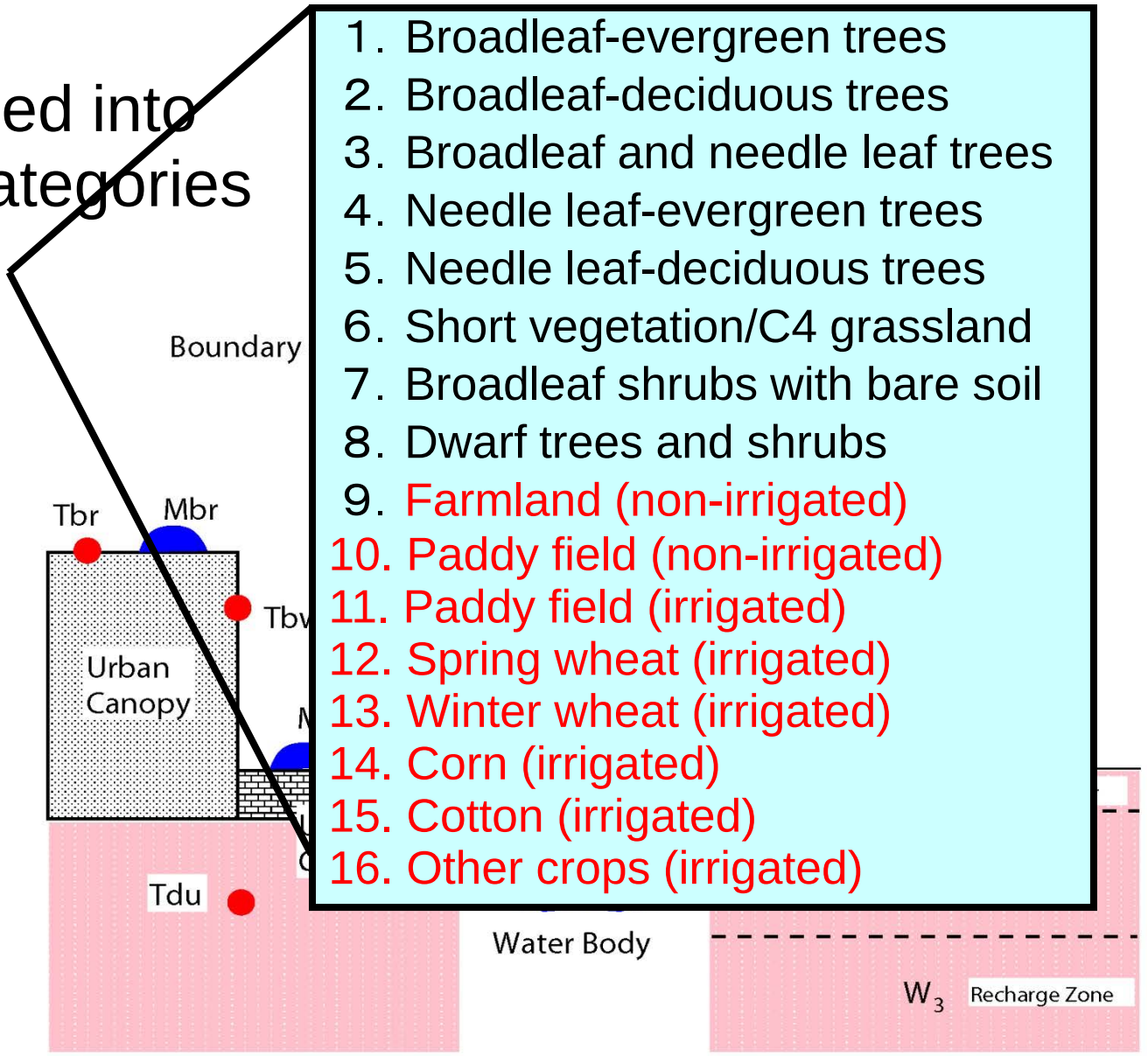
Land surface model



Land surface model (SiBUC)

Grid box is divided into three landuse categories

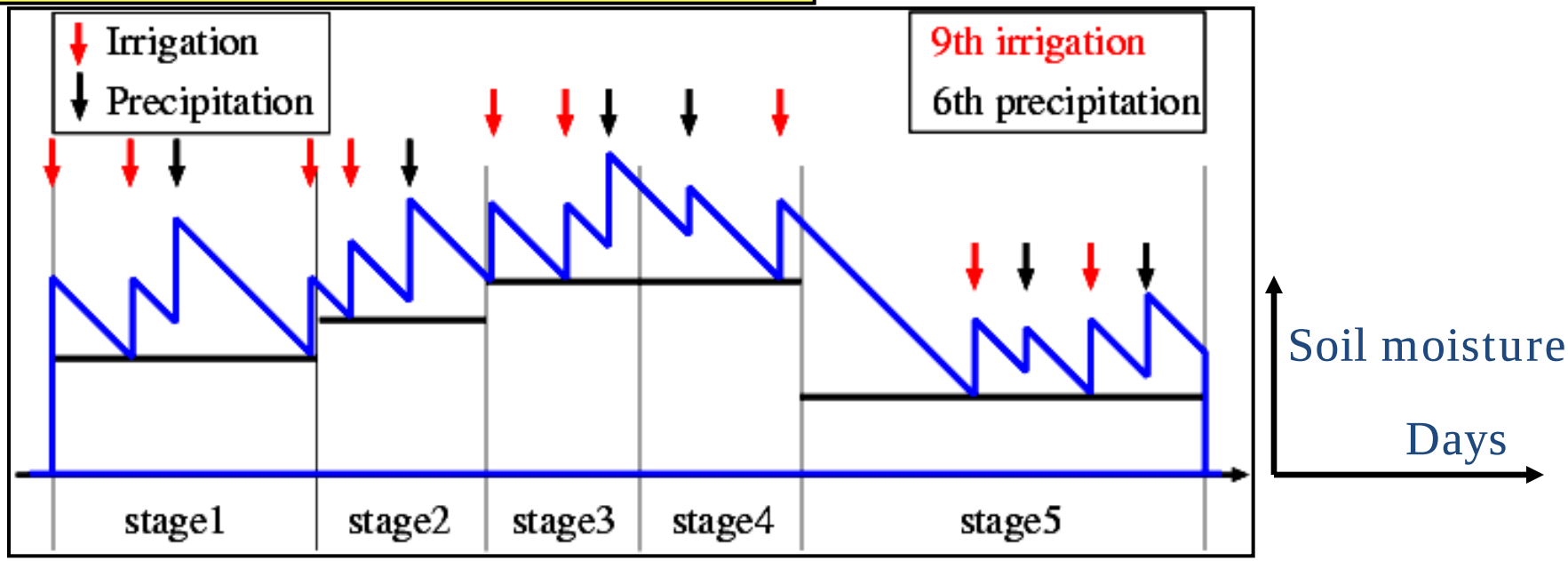
1. Green Area
2. Urban Area
3. Water Body



1. Broadleaf-evergreen trees
2. Broadleaf-deciduous trees
3. Broadleaf and needle leaf trees
4. Needle leaf-evergreen trees
5. Needle leaf-deciduous trees
6. Short vegetation/C4 grassland
7. Broadleaf shrubs with bare soil
8. Dwarf trees and shrubs
9. Farmland (non-irrigated)
10. Paddy field (non-irrigated)
11. Paddy field (irrigated)
12. Spring wheat (irrigated)
13. Winter wheat (irrigated)
14. Corn (irrigated)
15. Cotton (irrigated)
16. Other crops (irrigated)

Irrigation scheme

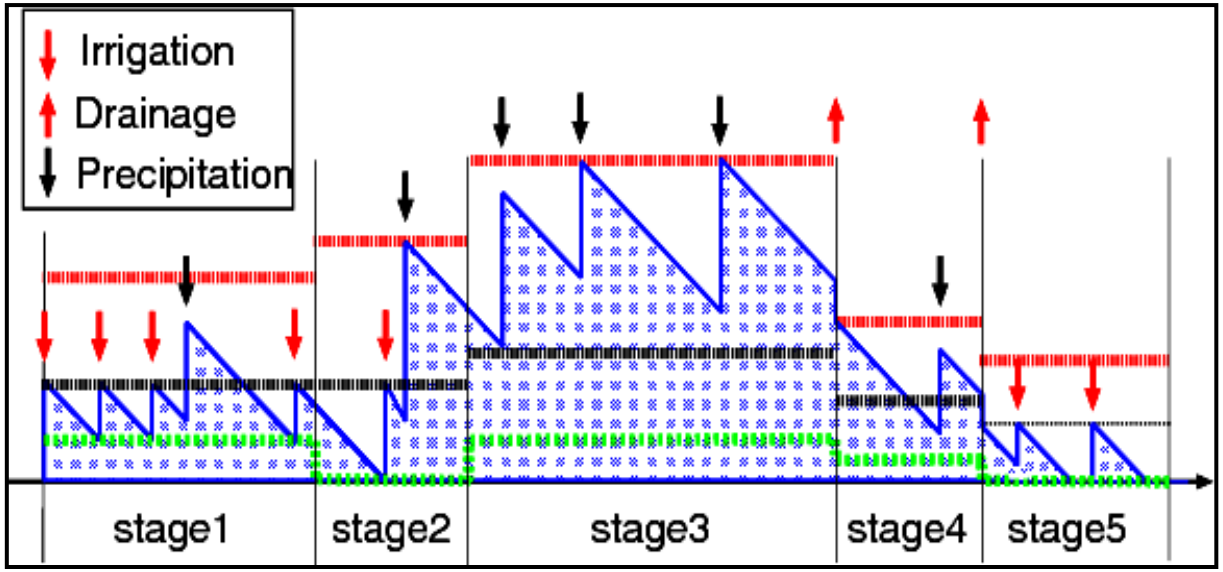
Water control in farmland

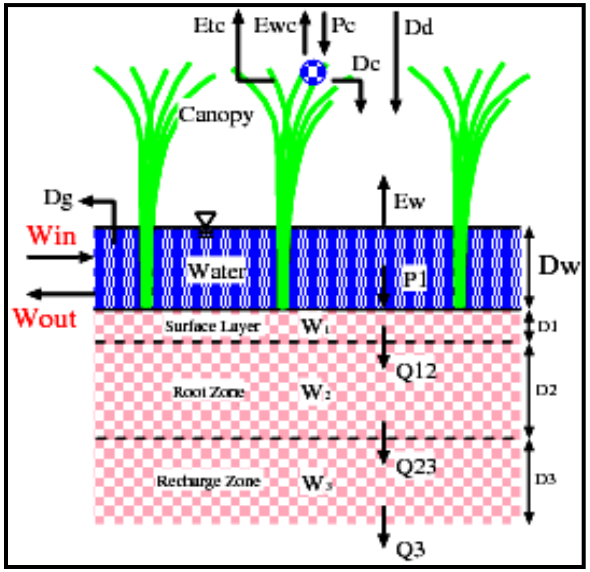


- Basic concept is to maintain water depth / soil moisture within appropriate ranges for optimal crop growth
- New water layer is added to treat paddy field more accurately
- Application to wheat, corn, soy bean and rice (paddy field) etc...

Irrigation scheme

Water control in paddy field





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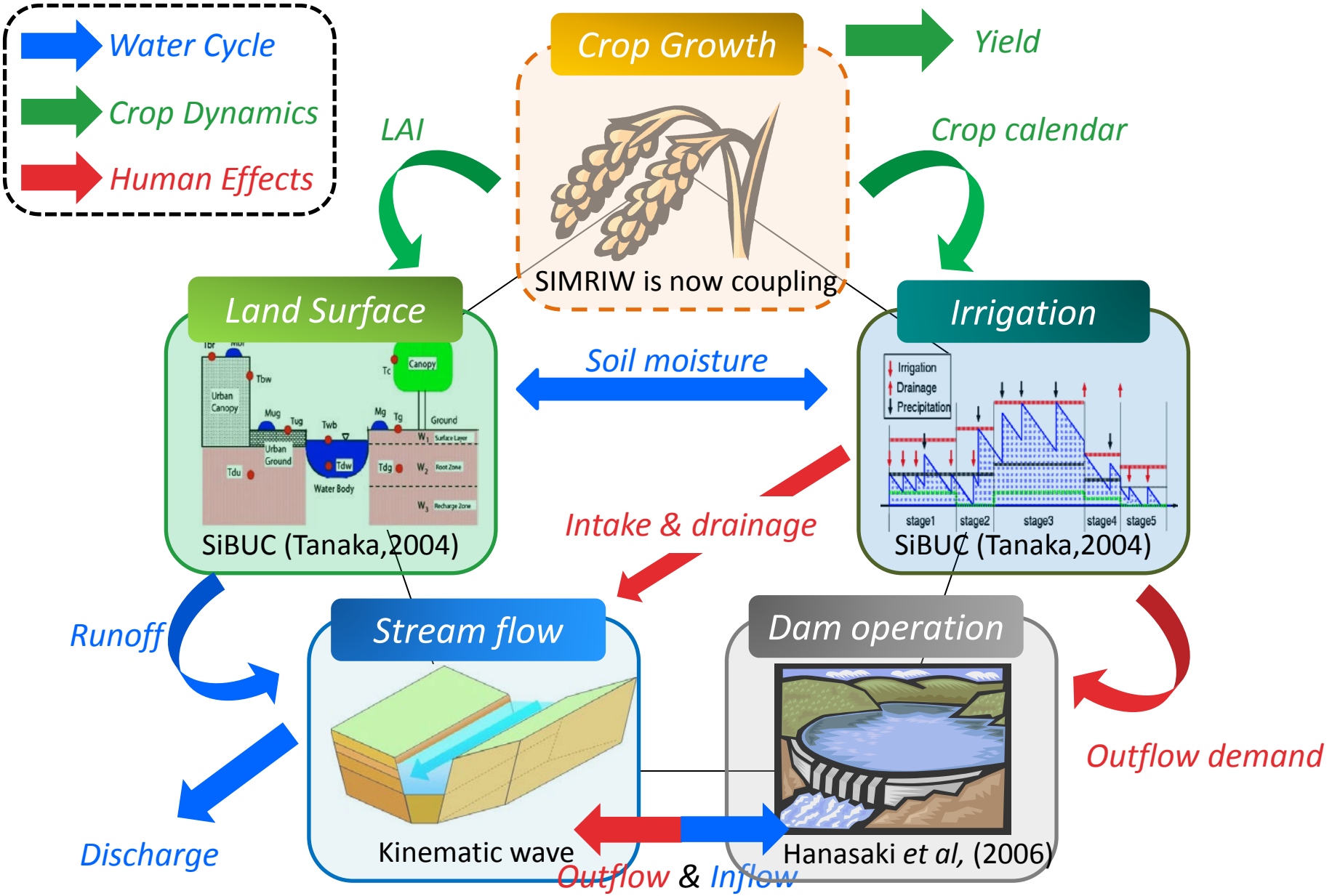
Integrated water resources model



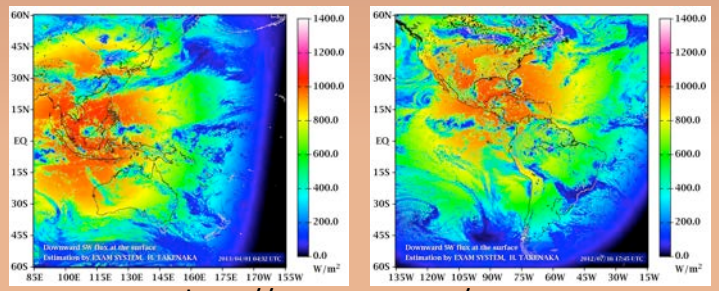
Food Security Package: Utilizing High Frequency Satellite Products with Integrated Land Process Models (SiBUC & SIMRIW) & Short-time Prediction with Cloud Resolving Model (CReSS)

High Time Frequency Forcing Data by RS

Precipitation: GSMaP

http://sharaku.eorc.jaxa.jp/GSMaP/

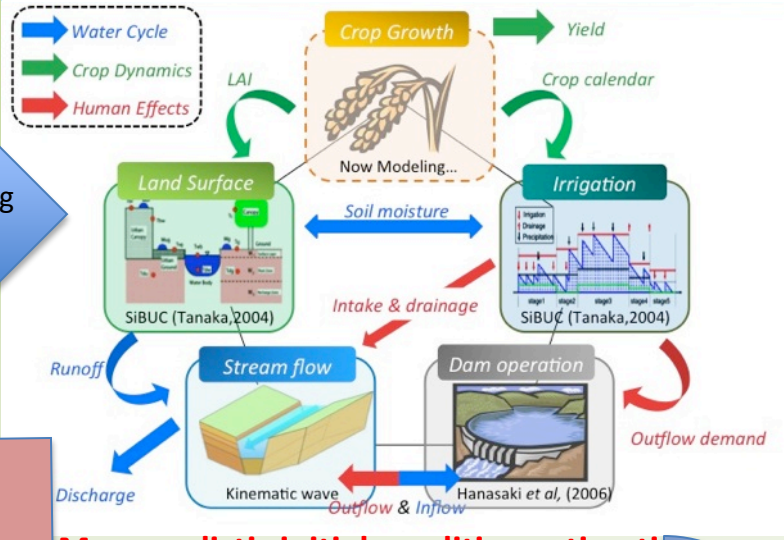
Solar Radiation: EXAM



http://amaterass.org/

"Real" Forcing to Model

Integrated Land Process Modeling
Hydrology [SiBUC]+ Crop Growth [SIMRIW]



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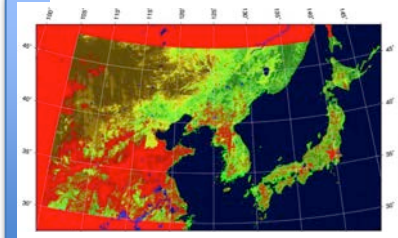
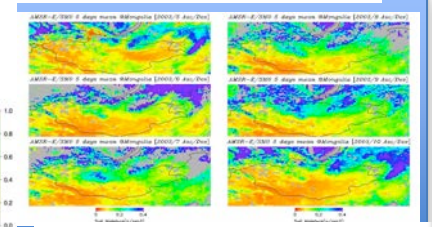


Biomass by Optical Sensor



Soil Moisture by AMSR2

Short-term Prediction by CReSS+SiBUC (CReSiBUC) (1-5 days forecast)

- Integrated Research Demonstration: Satellite Observation & Numerical Modeling
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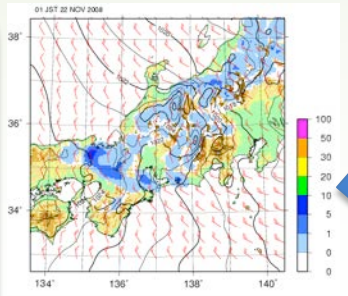
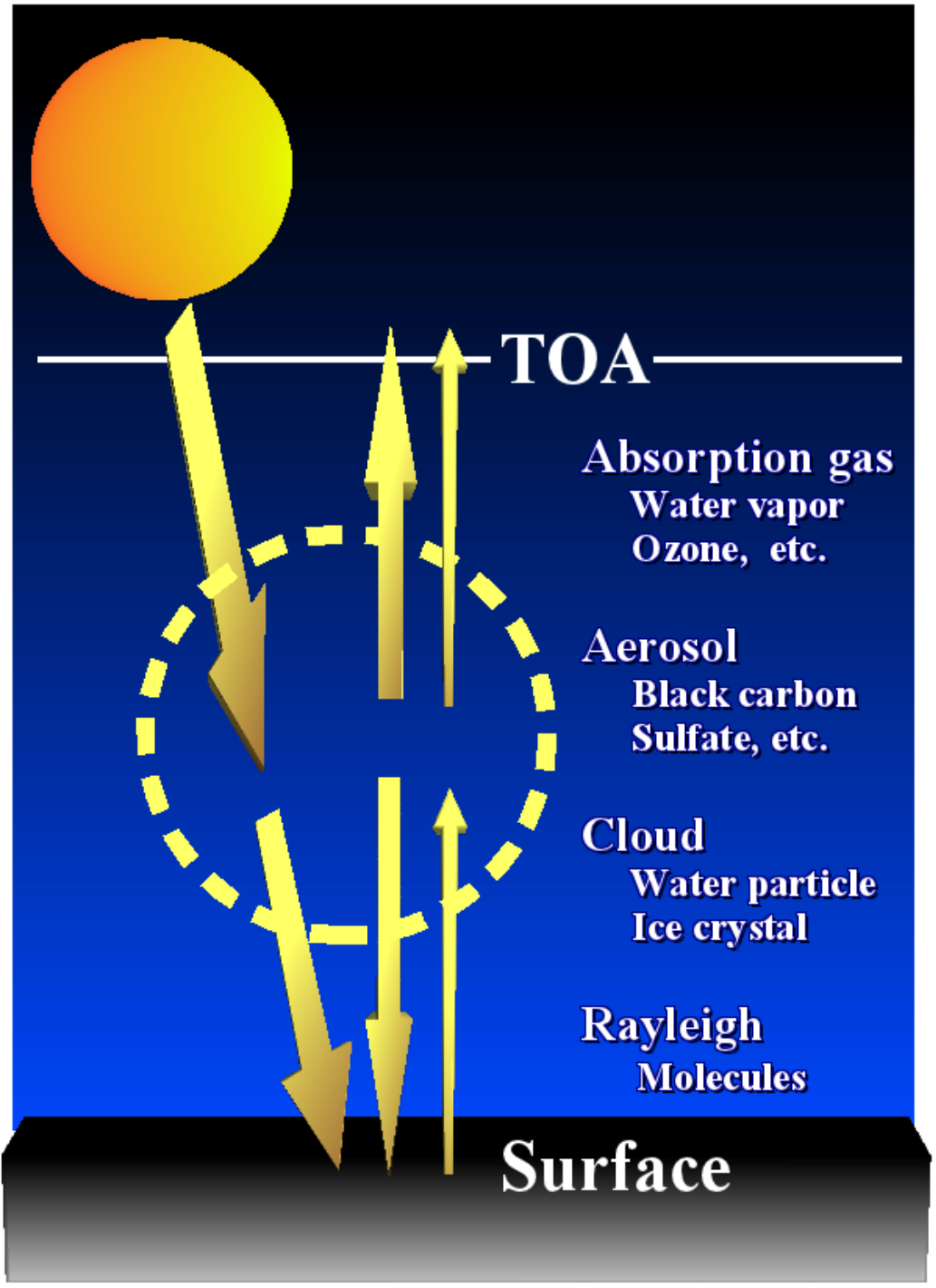
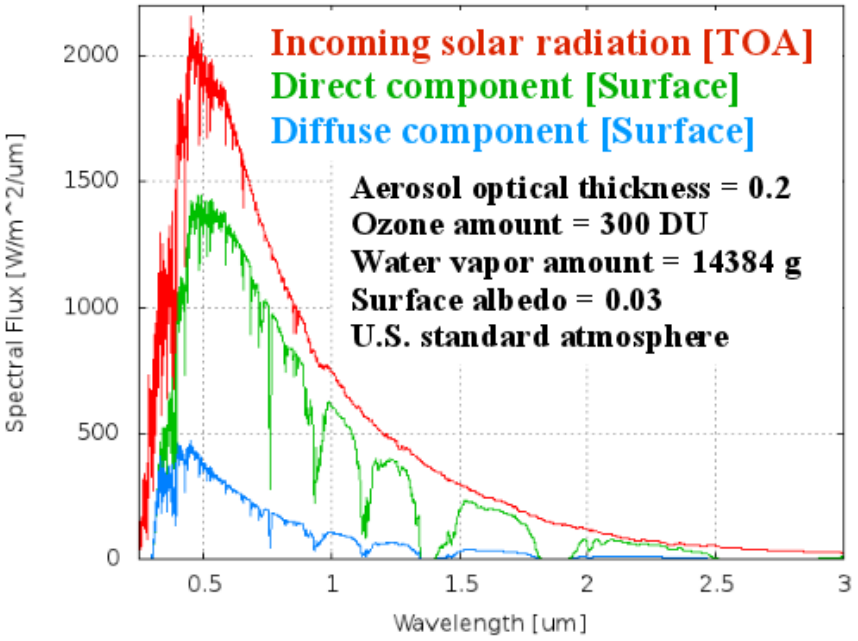
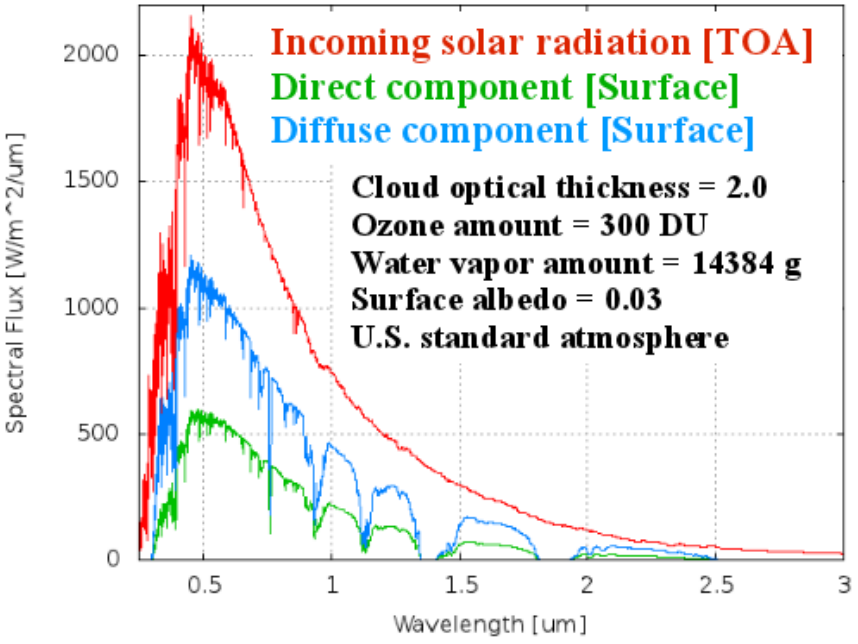
- Real-time system operation as a test of "infra-structure" for *food security.*




TOA
Absorption gas
Water vapor
Ozone, etc.
Aerosol
Black carbon
Sulfate, etc.
Cloud
Water particle
Ice crystal
Rayleigh
Molecules
Surface


Incoming solar radiation [TOA]
Direct component [Surface]
Diffuse component [Surface]
Aerosol optical thickness = 0.2
Ozone amount = 300 DU
Water vapor amount = 14384 g
Surface albedo = 0.03
U.S. standard atmosphere
Spectral Flux [W/m^2/um]
Wavelength [um]
0
500
1000
1500
2000
0.5
1
1.5
2
2.5
3


Incoming solar radiation [TOA]
Direct component [Surface]
Diffuse component [Surface]
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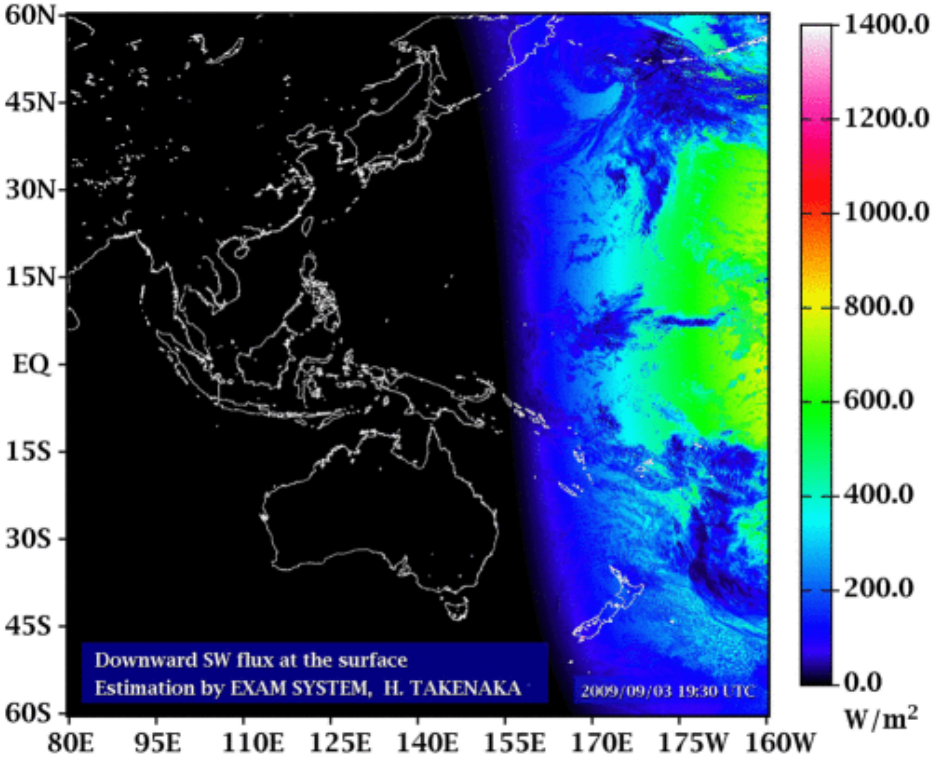
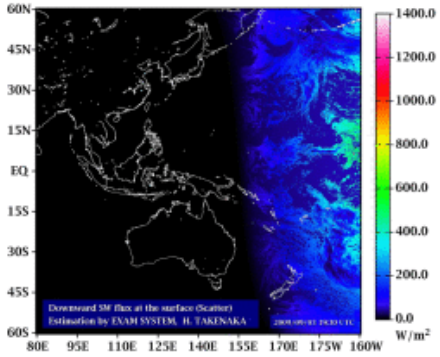
Ozone amount = 300 DU
Water vapor amount = 14384 g
Surface albedo = 0.03
U.S. standard atmosphere
Spectral Flux [W/m^2/um]
Wavelength [um]
0
500
1000
1500
2000
0.5
1
1.5
2
2.5
3

Atmospheric radiation budget product (from 2007 July 7)

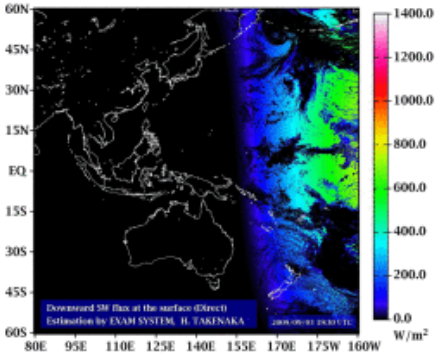
Downward SW flux at the surface



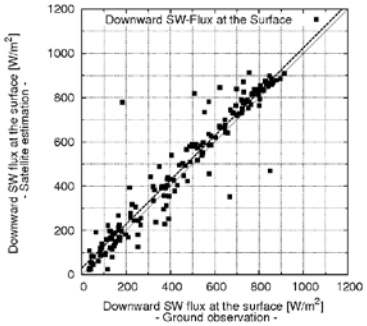
Diffuse SW

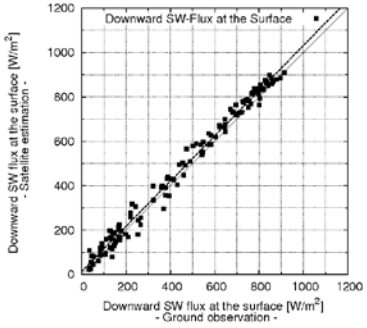


Direct SW

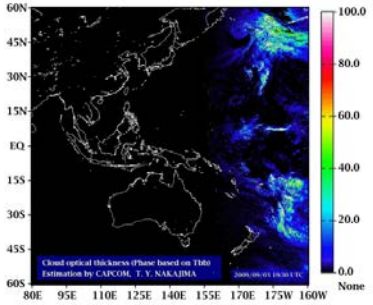


Ground validation of SW flux

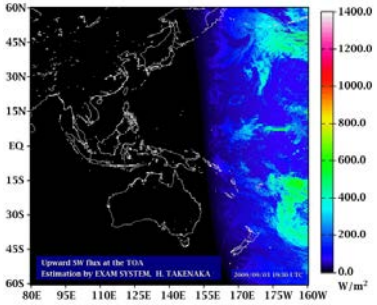




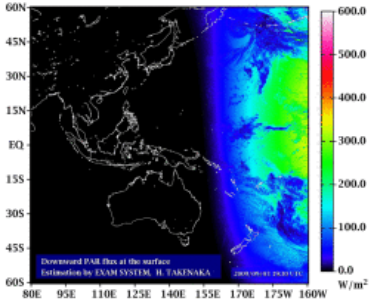
Cloud optical thickness



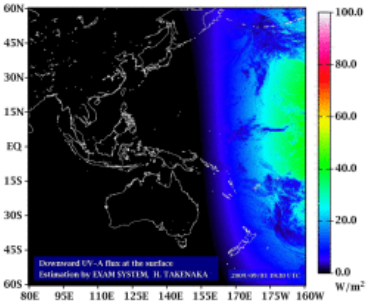
Upward SW flux at the TOA



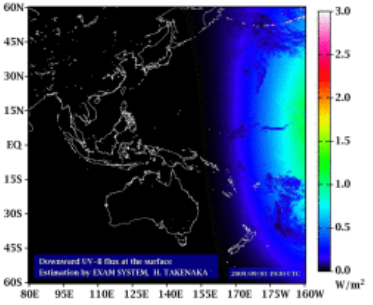
Downward PAR flux at the sfc



Downward UVA flux at the sfc

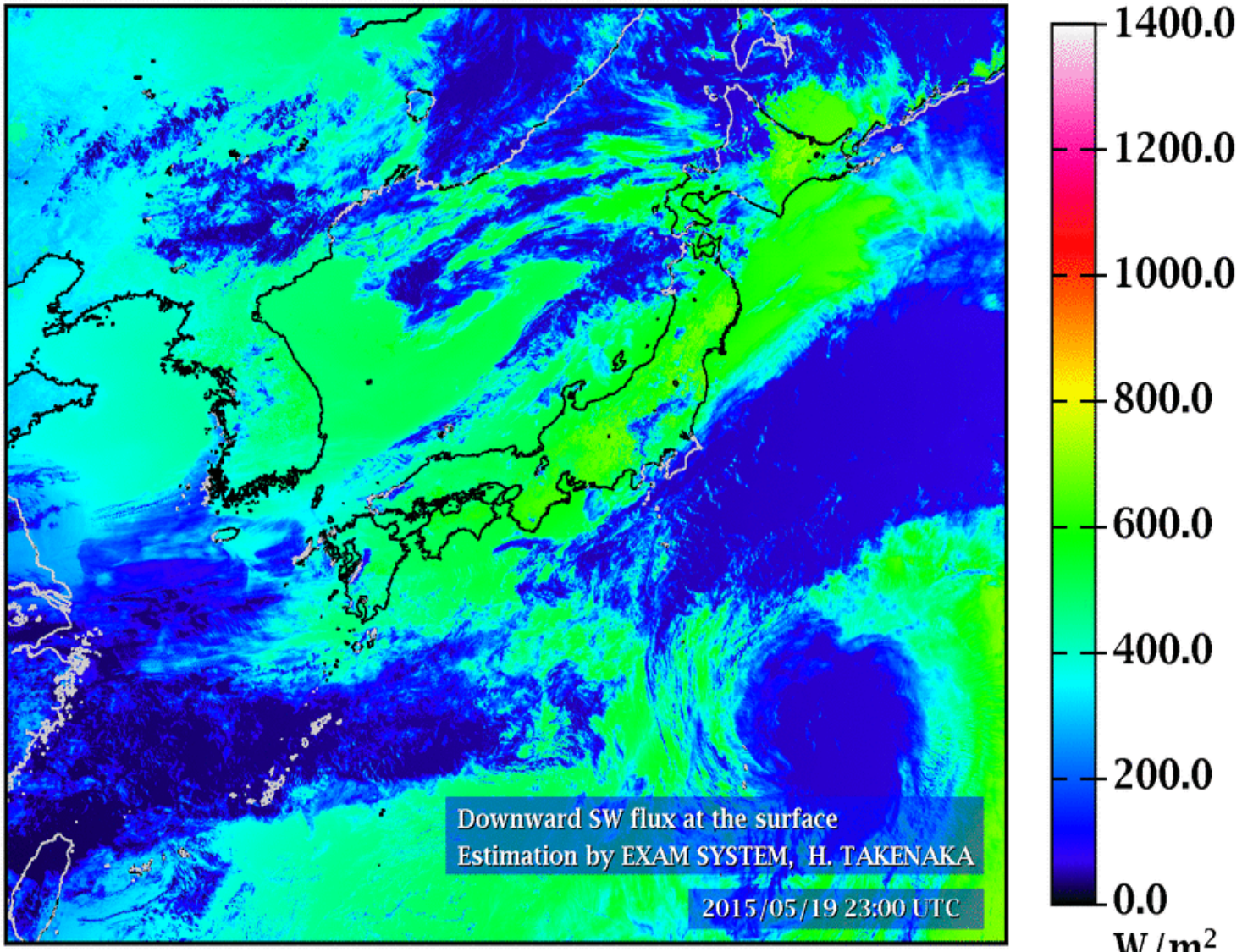


Downward UVB flux at the sfc



EXAM system estimates SW radiation by HIMAWARI-8

by Dr. H. Takenaka (JAXA EORC /CEReS CU)



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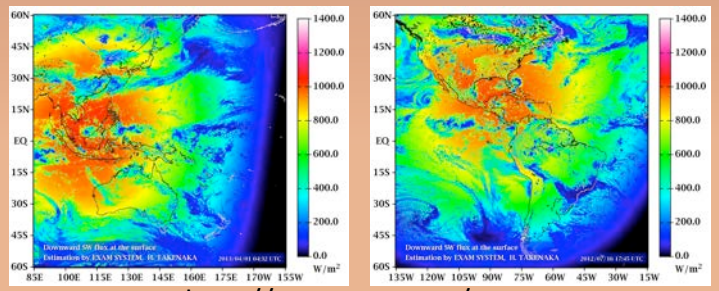

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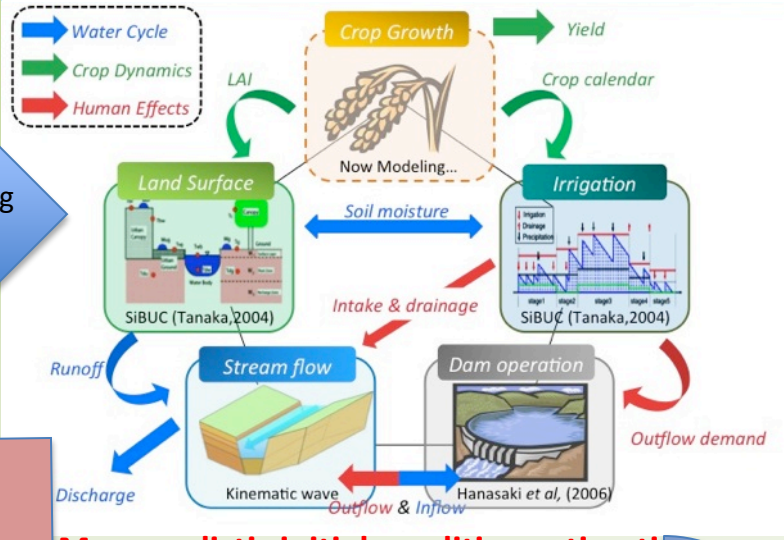

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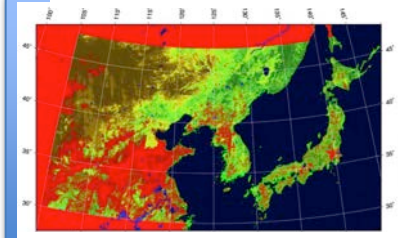

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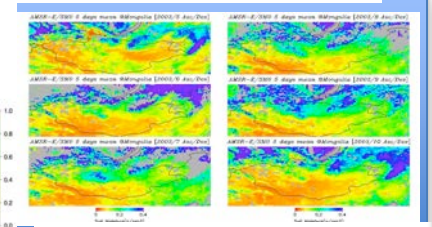

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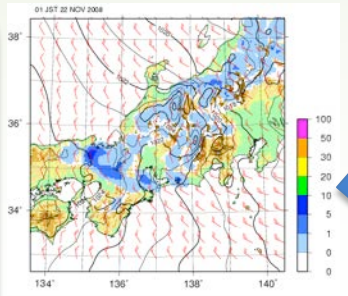
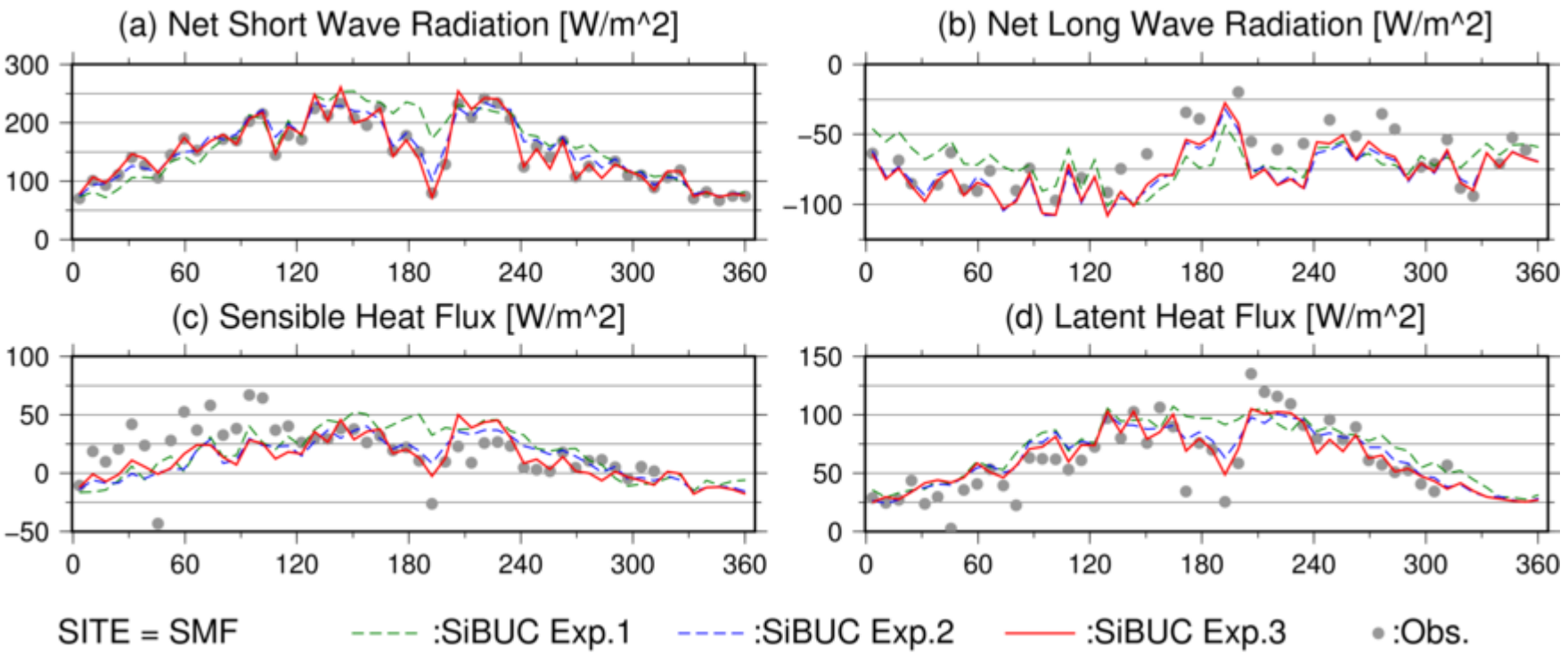


Effect of EXAM（Shortwave Radiation forcing）



Kotsuki et al (2015): HRL

-----: Exp.1 GPV/MSM, -----: Exp.2 JRA55, ——: Exp.3 JRA55+EXAM

Effect of EXAM (with in-situ JapanFlux observations)

Represented by correlation coefficient [R] & Root Mean Squire Error [RMSE]

Kotsuki et al (2015): HRL

Sites / Function		Experiment 1				Experiment 2				Experiment 3			
		SWn	LWn	SHF	LHF	SWn	LWn	SHF	LHF	SWn	LWn	SHF	LHF
FHK	R	–		0.413	0.790	–		0.478	0.779	–		0.689	0.767
	RMSE			39.4	37.9			32.3	27.1			28.0	24.5
SMF	R	0.720	0.483	0.233	0.528	0.899	0.837	0.434	0.653	0.953	0.879	0.566	0.699
	RMSE	52.9	28.6	36.6	42.3	32.9	21.6	31.7	37.2	22.8	19.5	29.4	34.7
TKC	R	0.740	0.386	–		0.833	0.724	–		0.922	0.783	–	
	RMSE	58.0	35.0			46.2	23.9			33.9	21.0		
TKY	R	0.676	0.396	0.486	0.762	0.856	0.726	0.532	0.828	0.945	0.781	0.663	0.893
	RMSE	65.0	40.6	30.5	36.9	46.5	30.6	27.2	25.8	28.4	28.4	23.2	22.7

SWn: Net-SW Radiation, LWn: Net-LW Radiation, SHF: Sensible Heat Flux, LHF: Latent Heat Flux

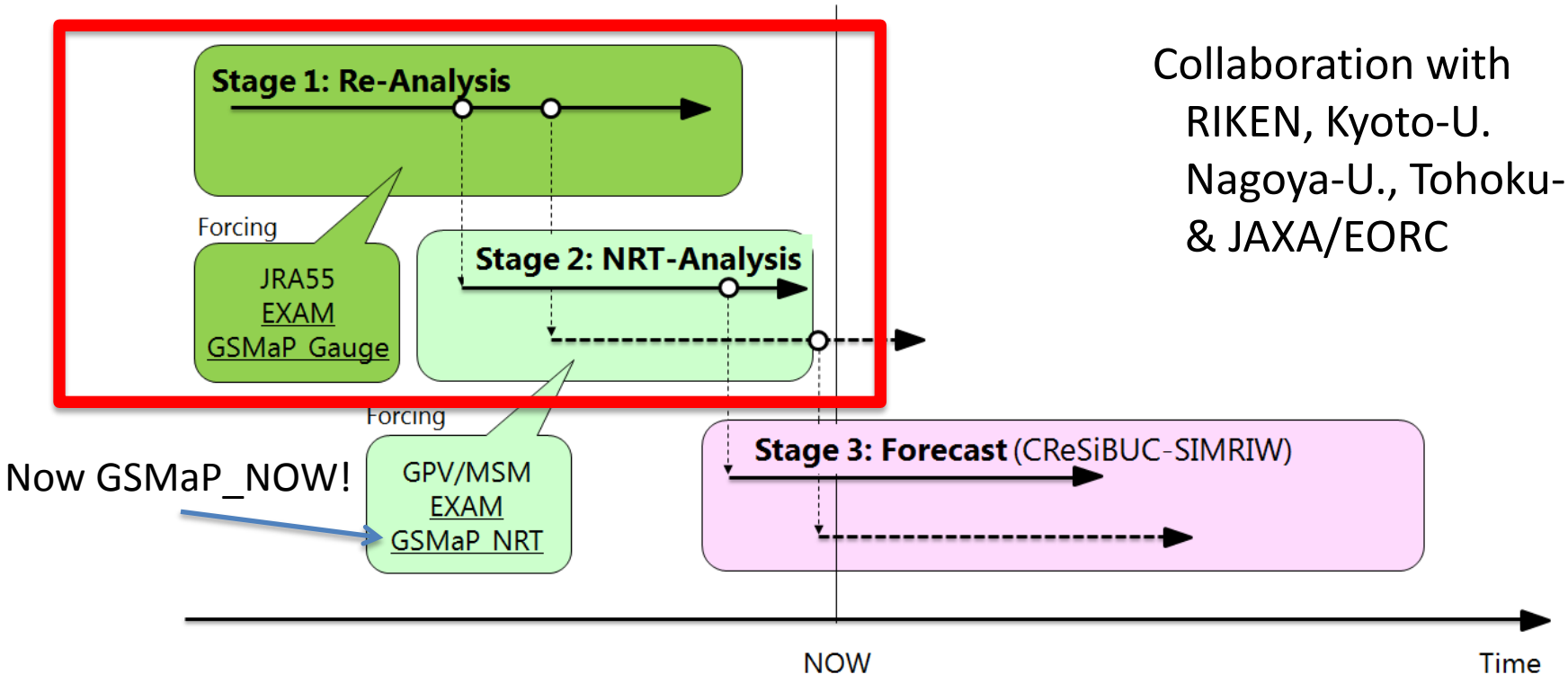
Best

Worst

-----: Exp.1 GPV/MSM, -----: Exp.2 JRA55, ——: Exp.3 JRA55+EXAM

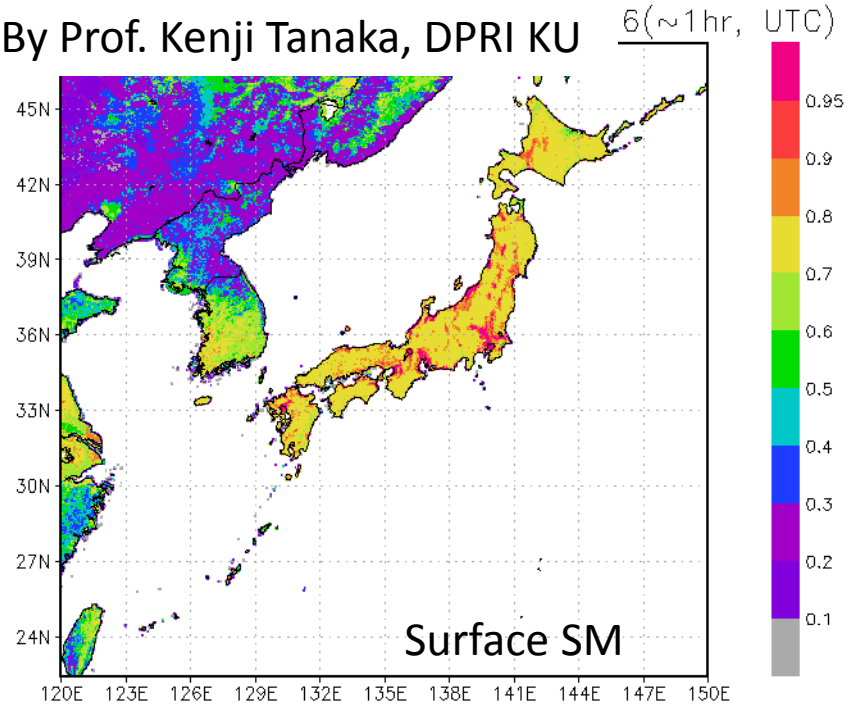
Real-time Land Surface Monitoring @ Chiba-U.

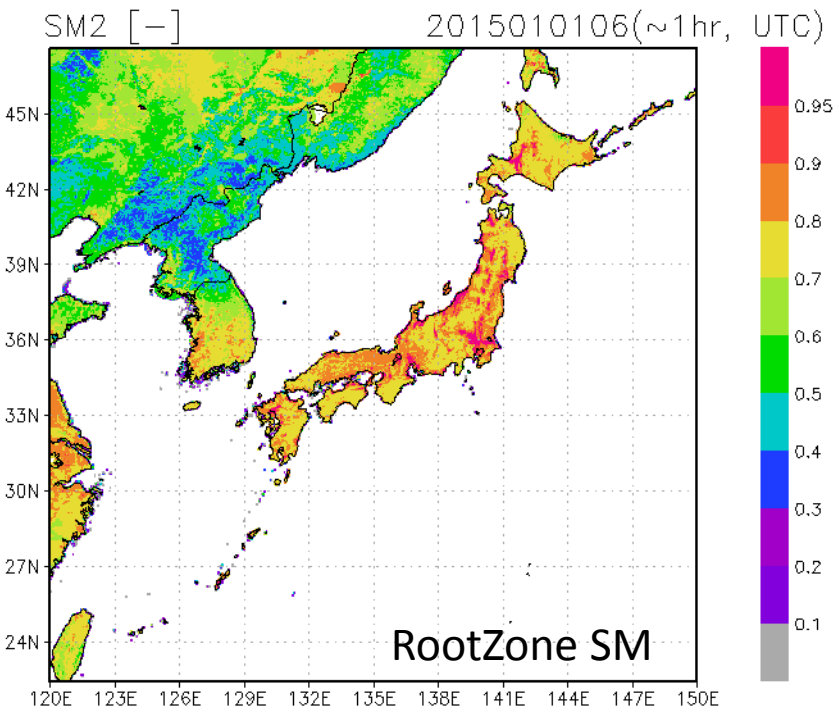
- **Re-Analysis (few-days delay)**
  - EXAM, JRA55, GSMaP/Gauge
- **Near Real-Time (NRT) Analysis (few hours delay)**
  - EXAM, GPV.MSM, GSMaP (GSMaP/Now < NRT < Gauge)
- **Forecast**
  - Numerical forecast with an atmospherics model

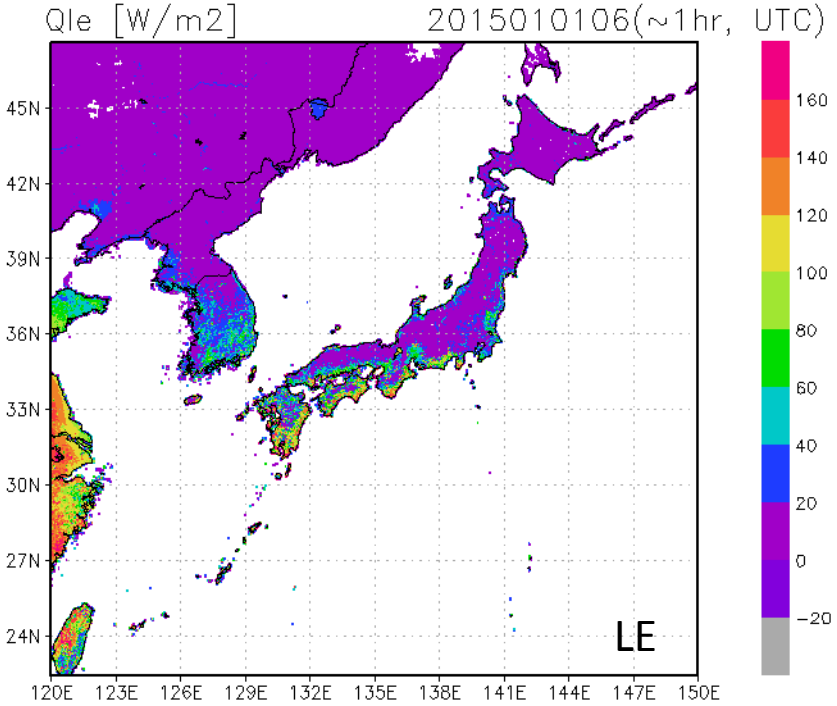


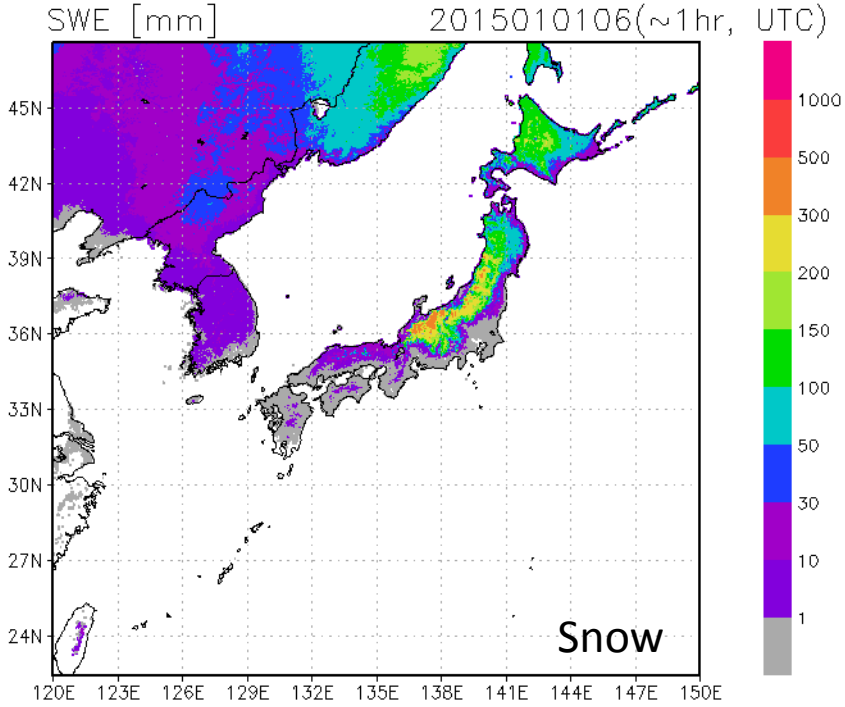
Collaboration with
RIKEN, Kyoto-U.
Nagoya-U., Tohoku-U.
& JAXA/EORC

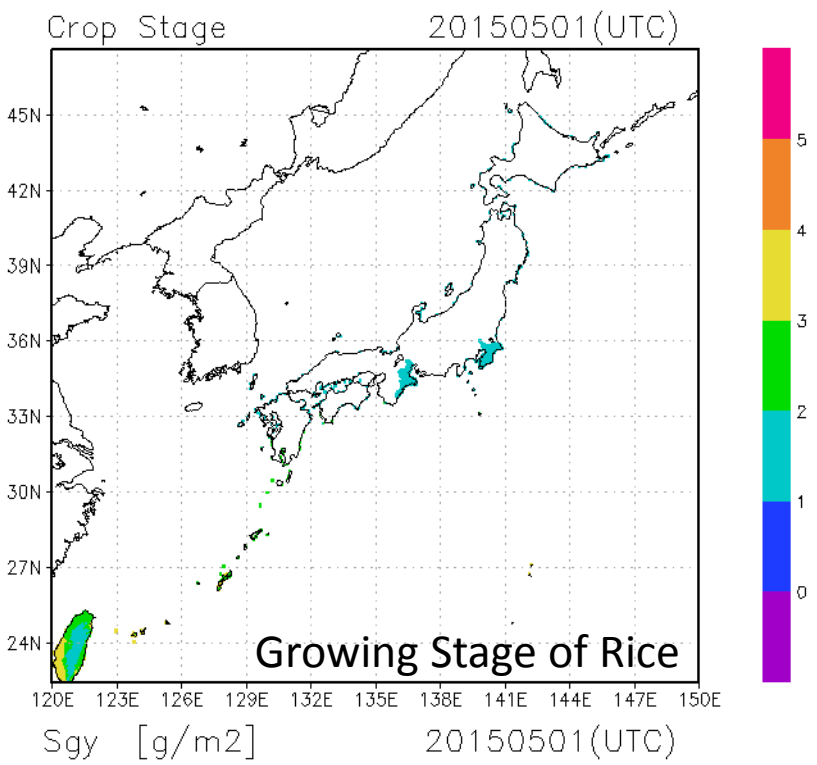
By Prof. Kenji Tanaka, DPRI KU

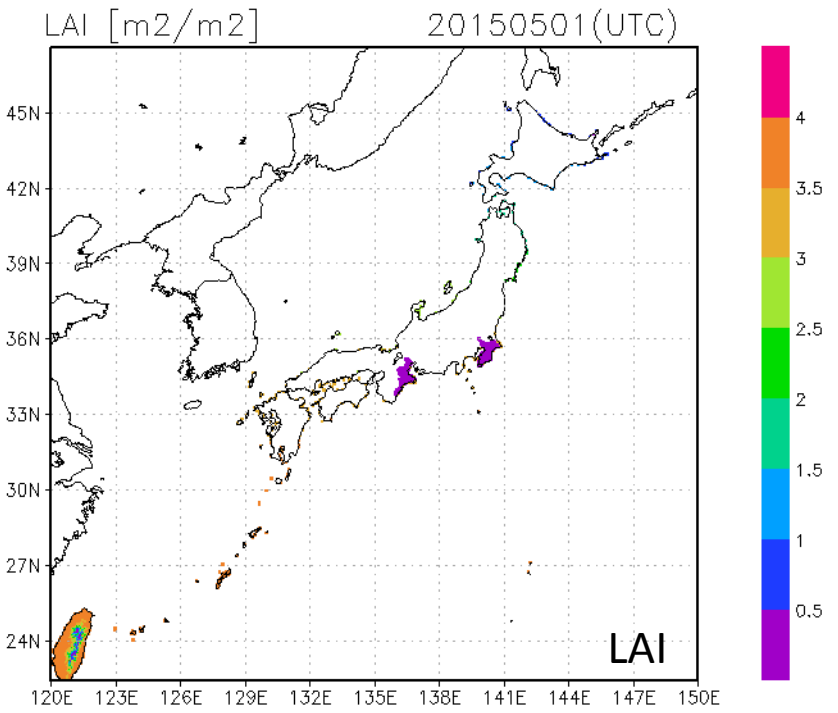












EXAM + GSMaP drive SIBUC+SIMRIW

AGB of Rice (yield)

Forecast (CReSiBUC-SIMRIW @ ISEE Nagoya-U.)

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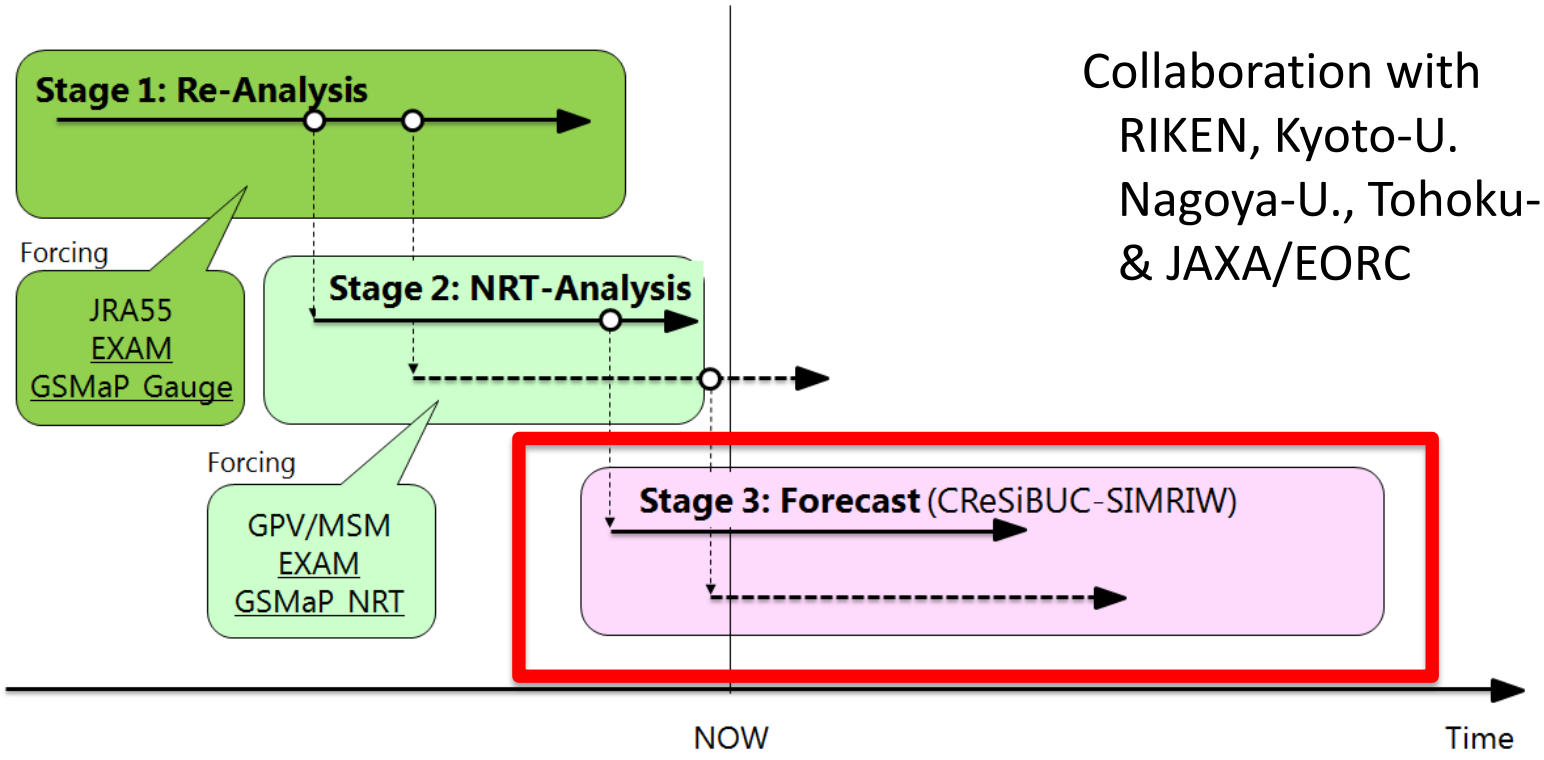
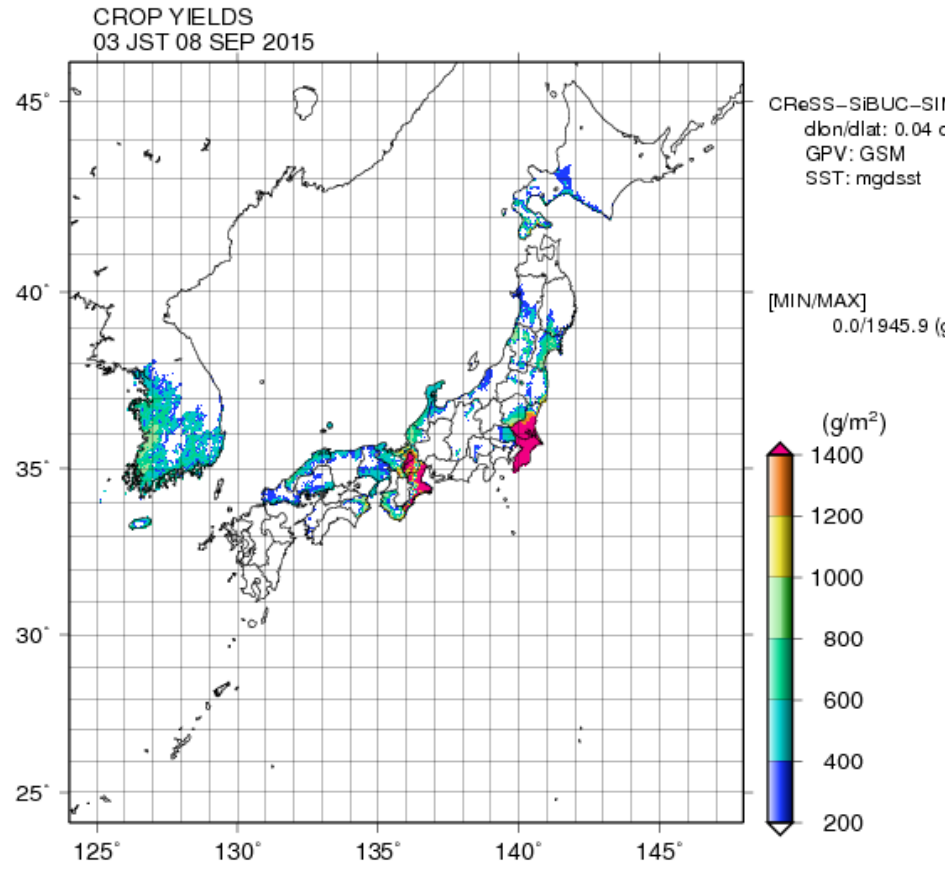
- **Forecast**
  - Numerical forecast with an atmospherics model



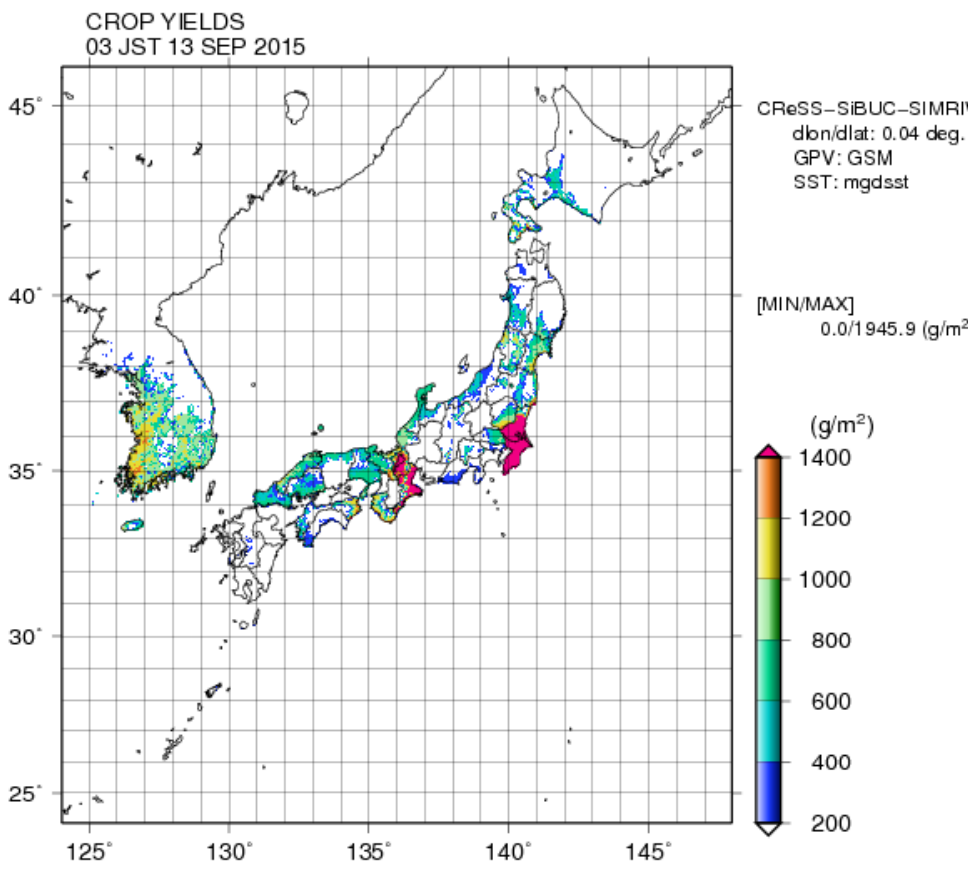
Collaboration with
RIKEN, Kyoto-U.
Nagoya-U., Tohoku-U.
& JAXA/EORC

Forecast examples : Estimated yield of rice

1day forecast

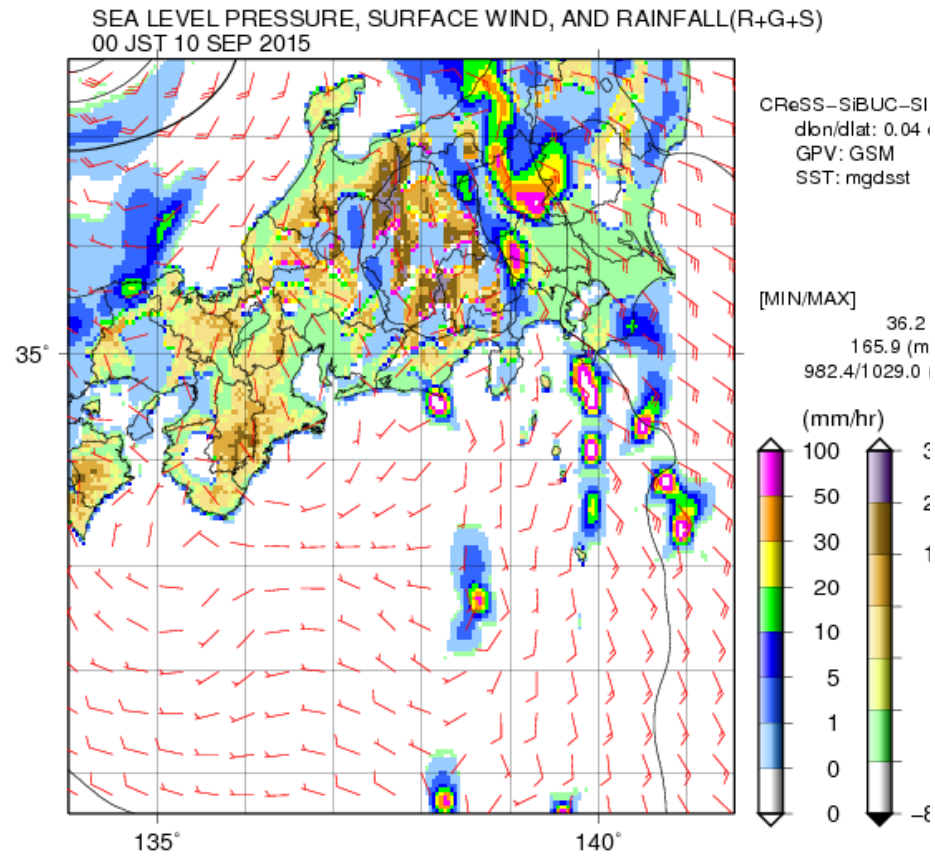


7days forecast

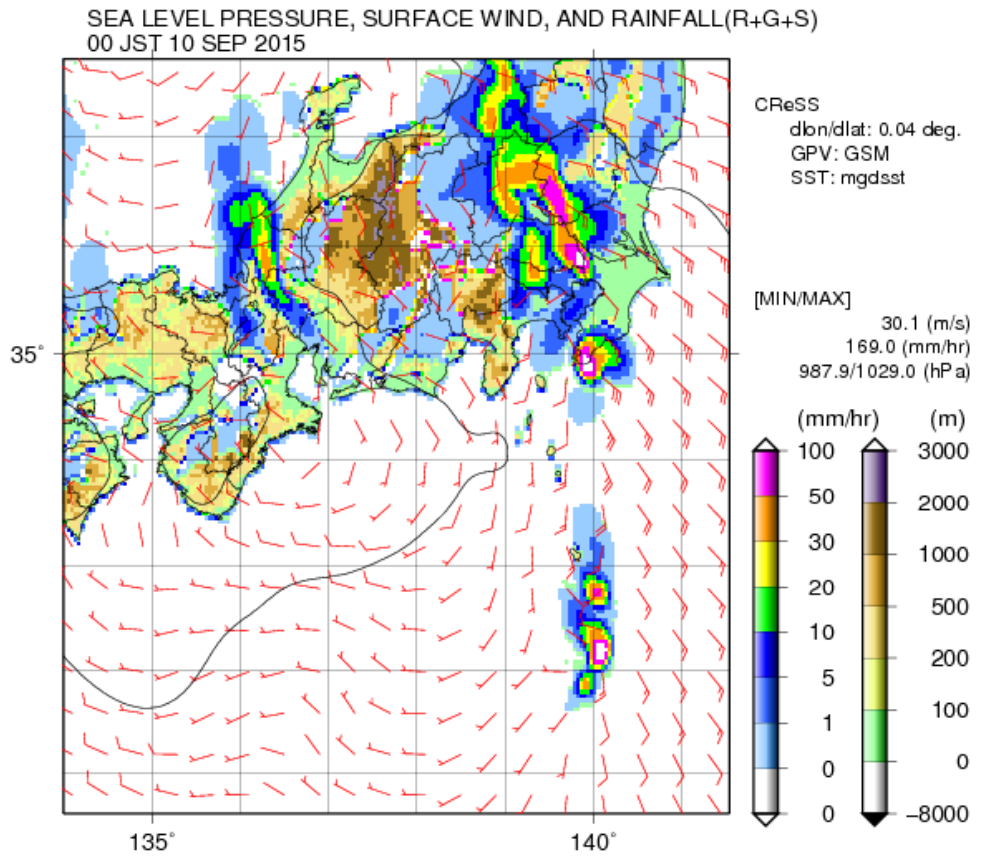


Improved surface process can improve rainfall?（鬼怒川豪雨事例）

CReSiBUC-SIMRIW



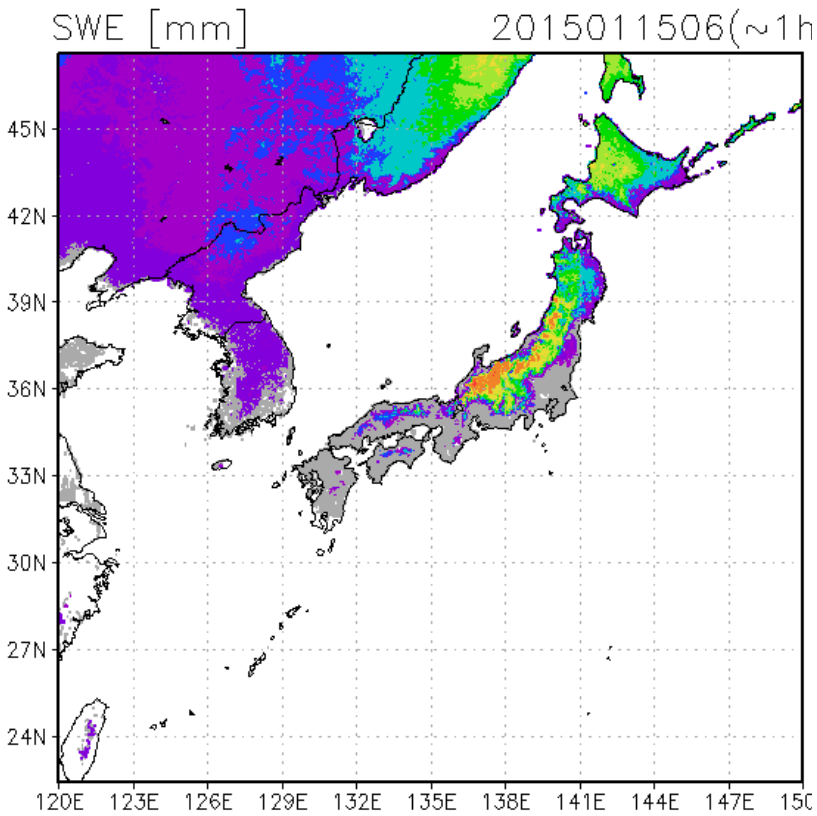
CReSS



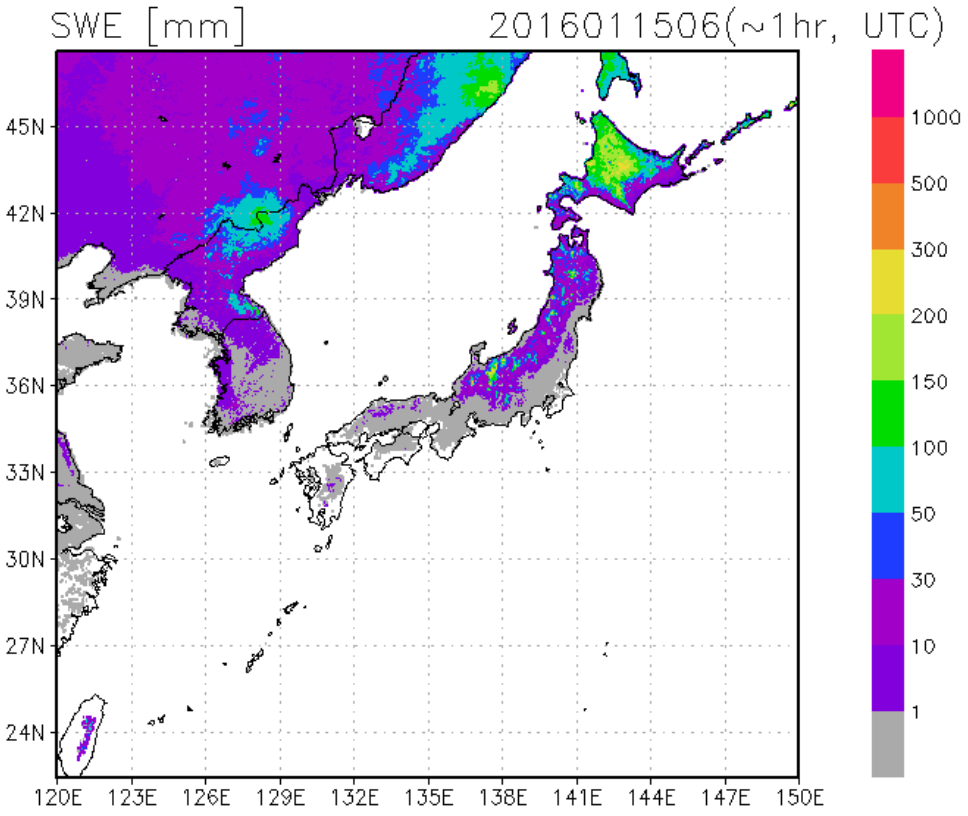
- No significant difference, but changed
- It seems better in CReSS only …

Climate change representation
Snow Water Equivalent (Snow Depth)

2015/Jan/15 (Normal Winter)

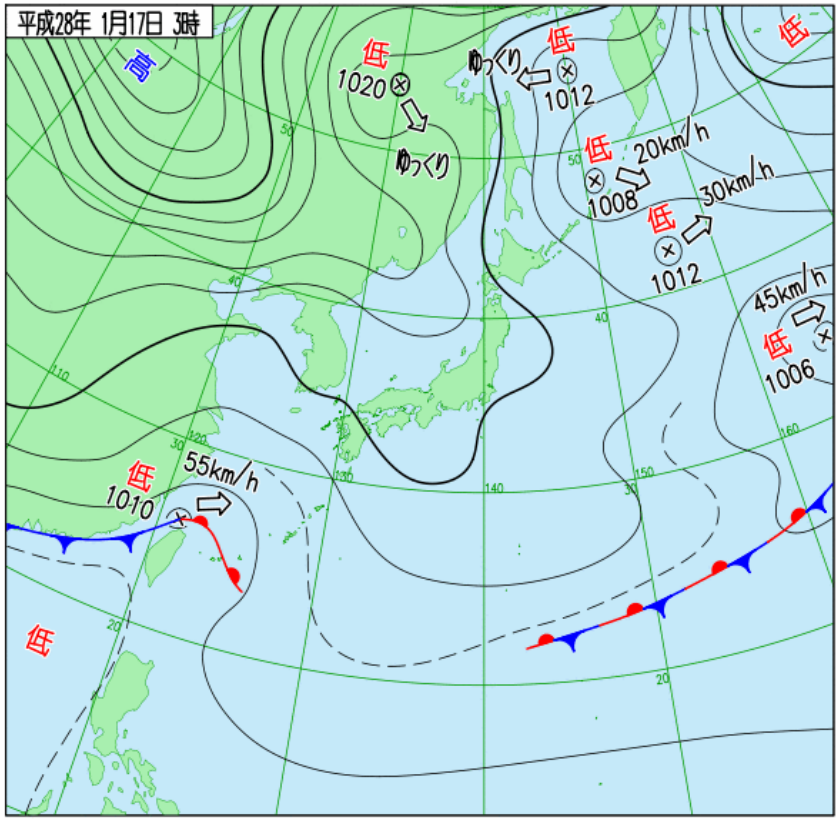


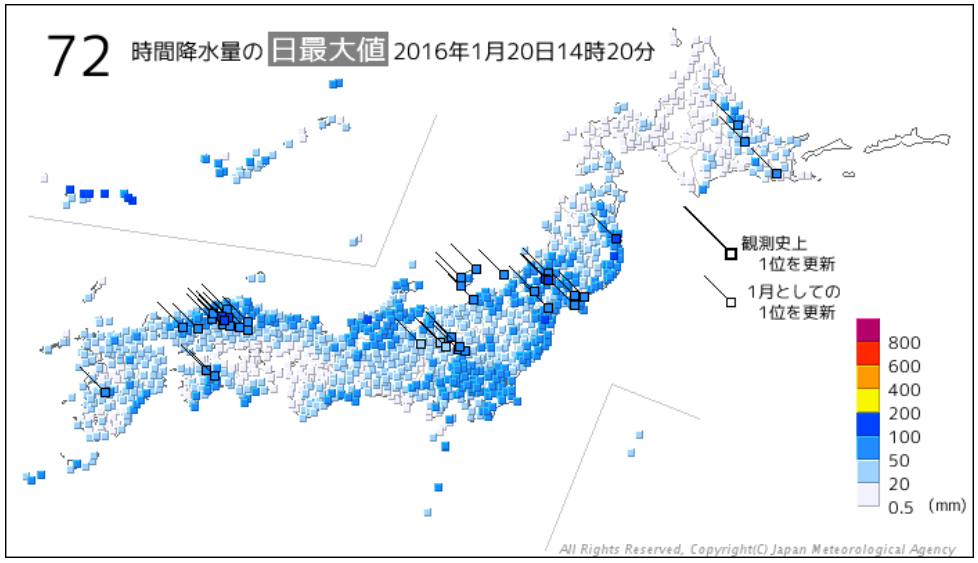
2016/Jan/15 (Warmer Winter)



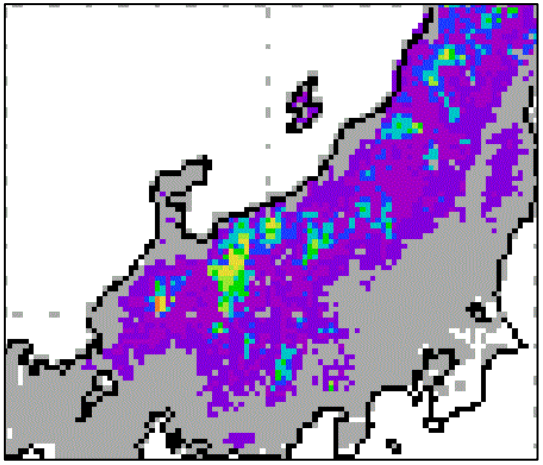
Snow depth

(SWE increase after frontal-low passed)

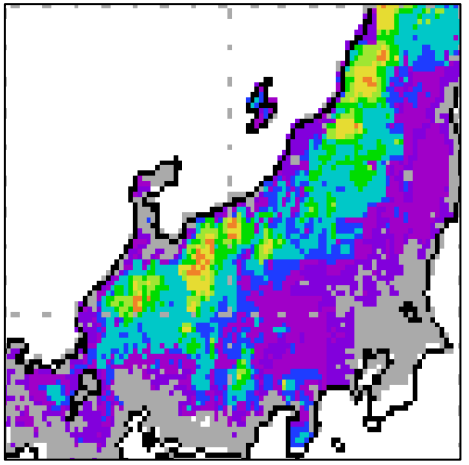




2016/Jan/17



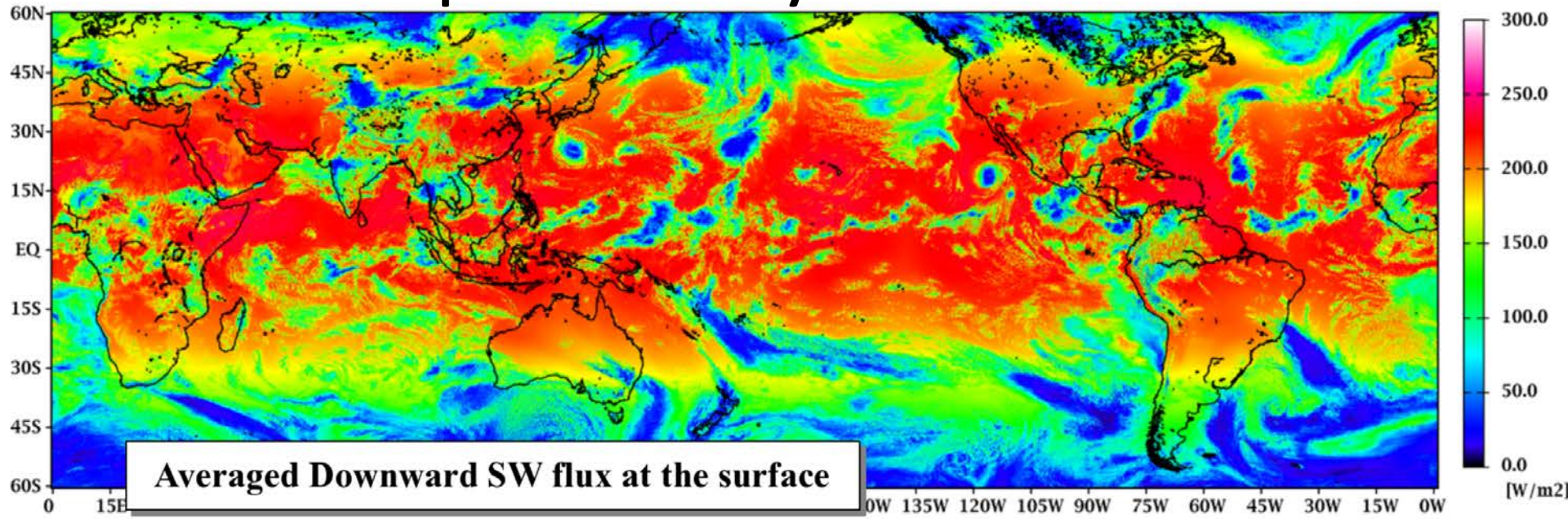
2016/Jan/20

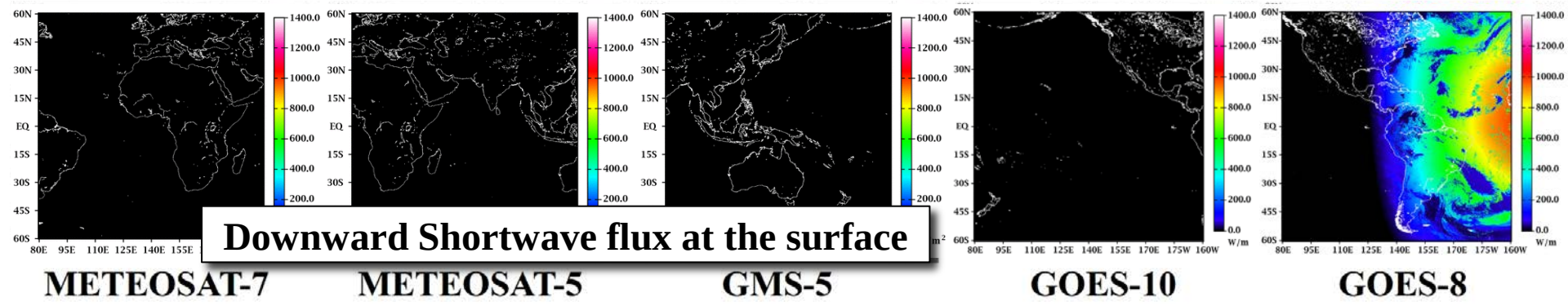


Concluding Remarks

- FD Package:
  - We developed ‘seamless’ package: By utilize H-8 derived products (forcing: Solar radiation [EXAM], precipitation [GSMaP]), Re-analysis (few days delay), Near-RT (few hours delay) and forecast system with SiBUC-SIMRIW and CReSiBC-SIMRIW.
  - Now we try to validate our package outputs by several satellite sensors retrieved outputs.
- Future Perspectives:
  - Expansion to “globe”: Use five GEO satellites, EXAM outputs will use for global scale. In addition, major crops yield estimation is next our target under collaboration with NARO crop modeling team.
  - More dynamic use of 3rd GEO: A kind of assimilation can improve monitor crop-stage adjustment by dynamic use of H-8 type GEO (3rd Generation GEO).

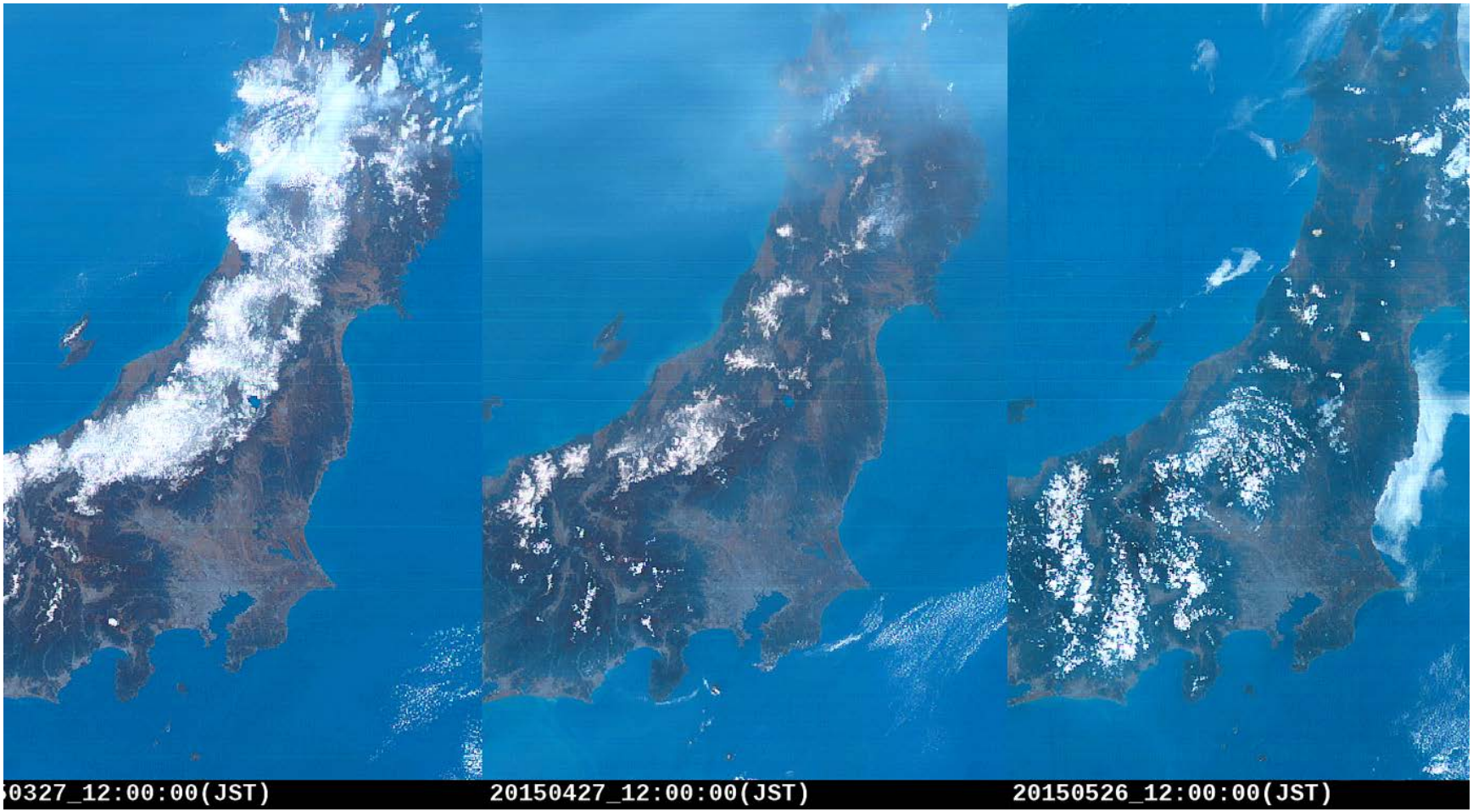
Proto-type EXAM global merged product by five-GEOs



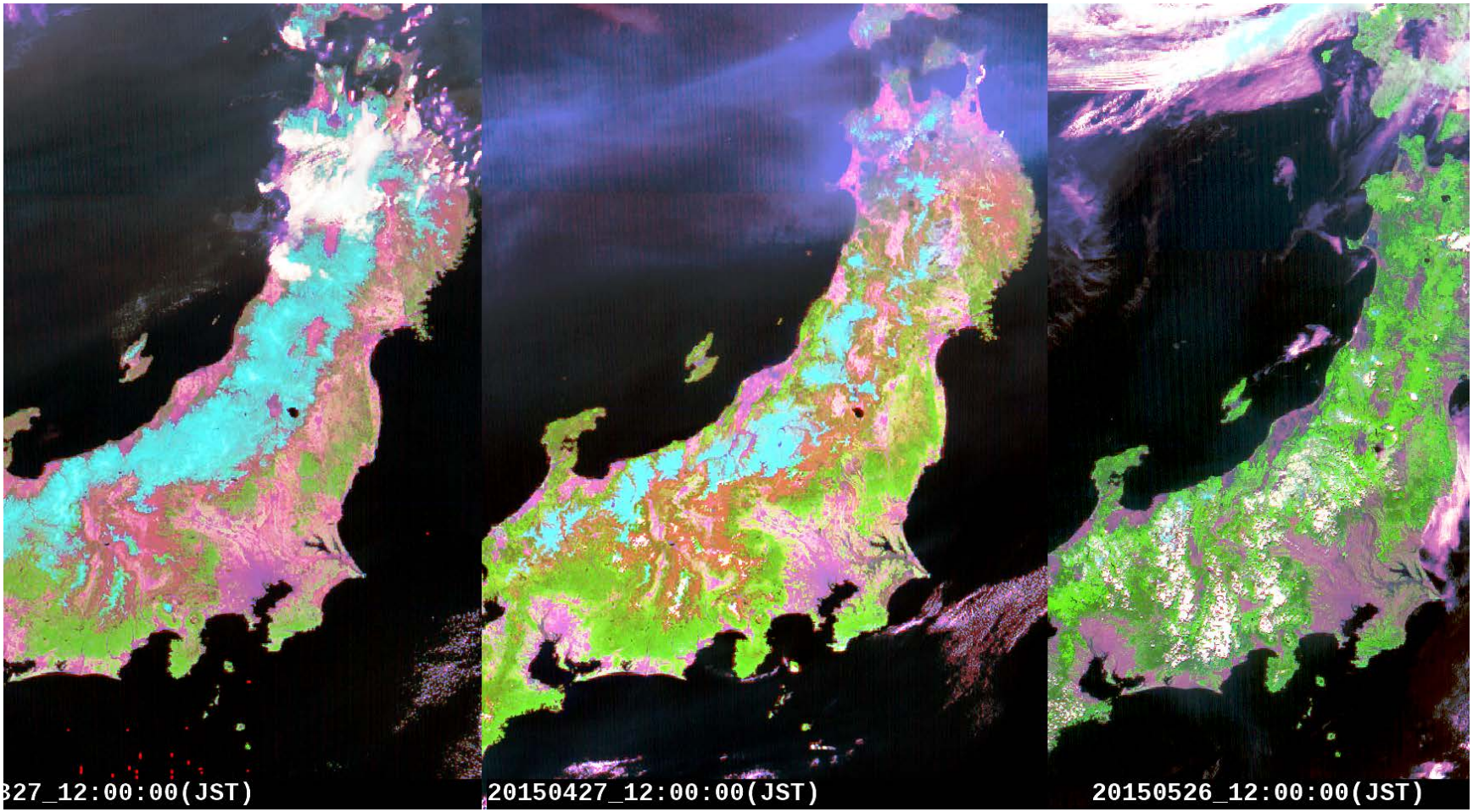


✓(Upper) no significant inter-platform difference by merging
→Success in inter-calibration of each GEO's radiometer

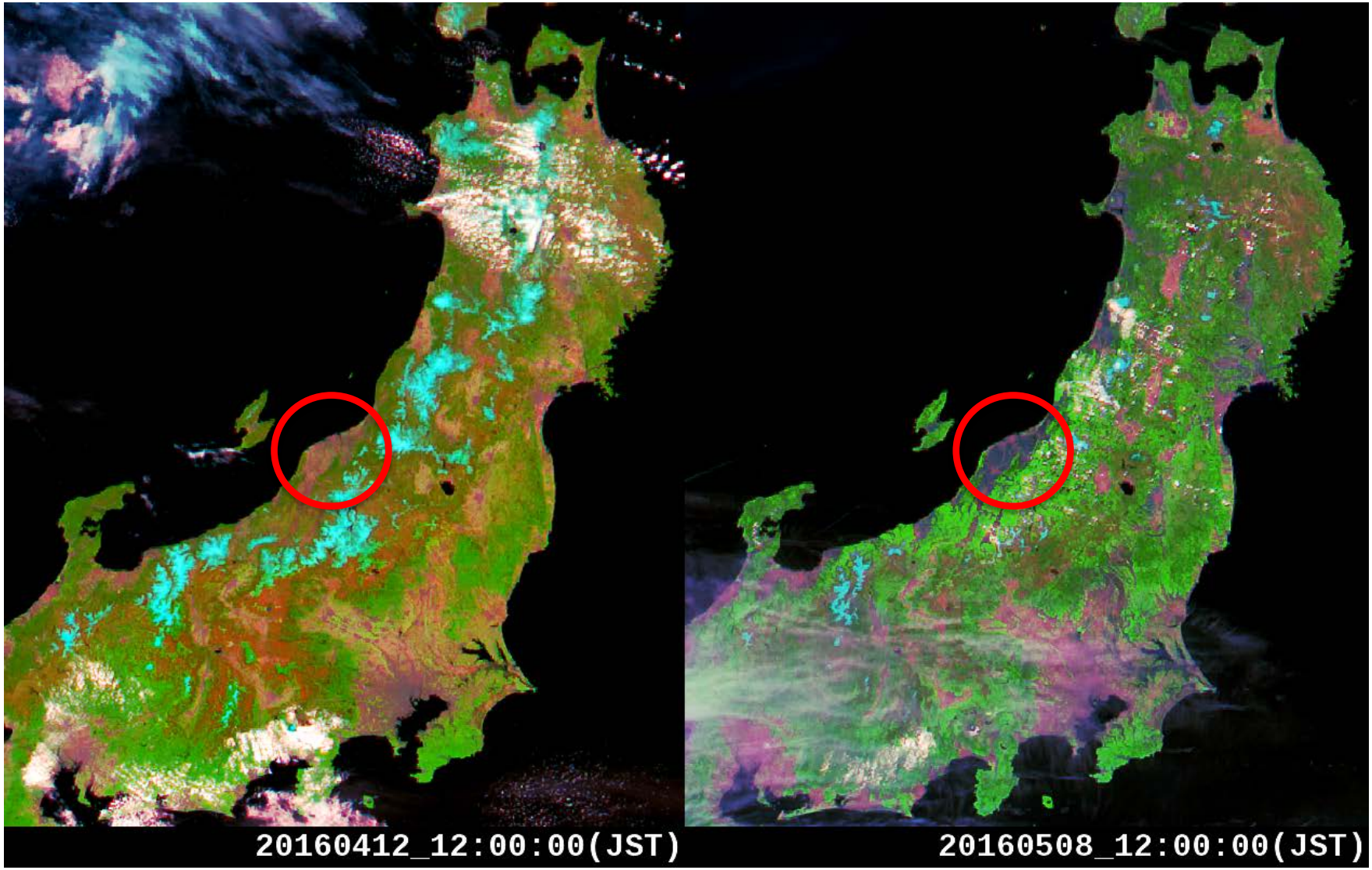
Natural Color RGB (R:R, G:G, B:B)



RGB composition change (R:R, G:NIR, B:1micron）by H-8



East-Japan (start to irrigation in May)



West-Japan (Winter Wheat – Rice)