IMPAC-T

Integrated study on Hydro-Meteorological Prediction and Adaptation to Climate Change in Thailand

Rainfall Estimation Model in Thailand based on Satellite Observations and Its Applications

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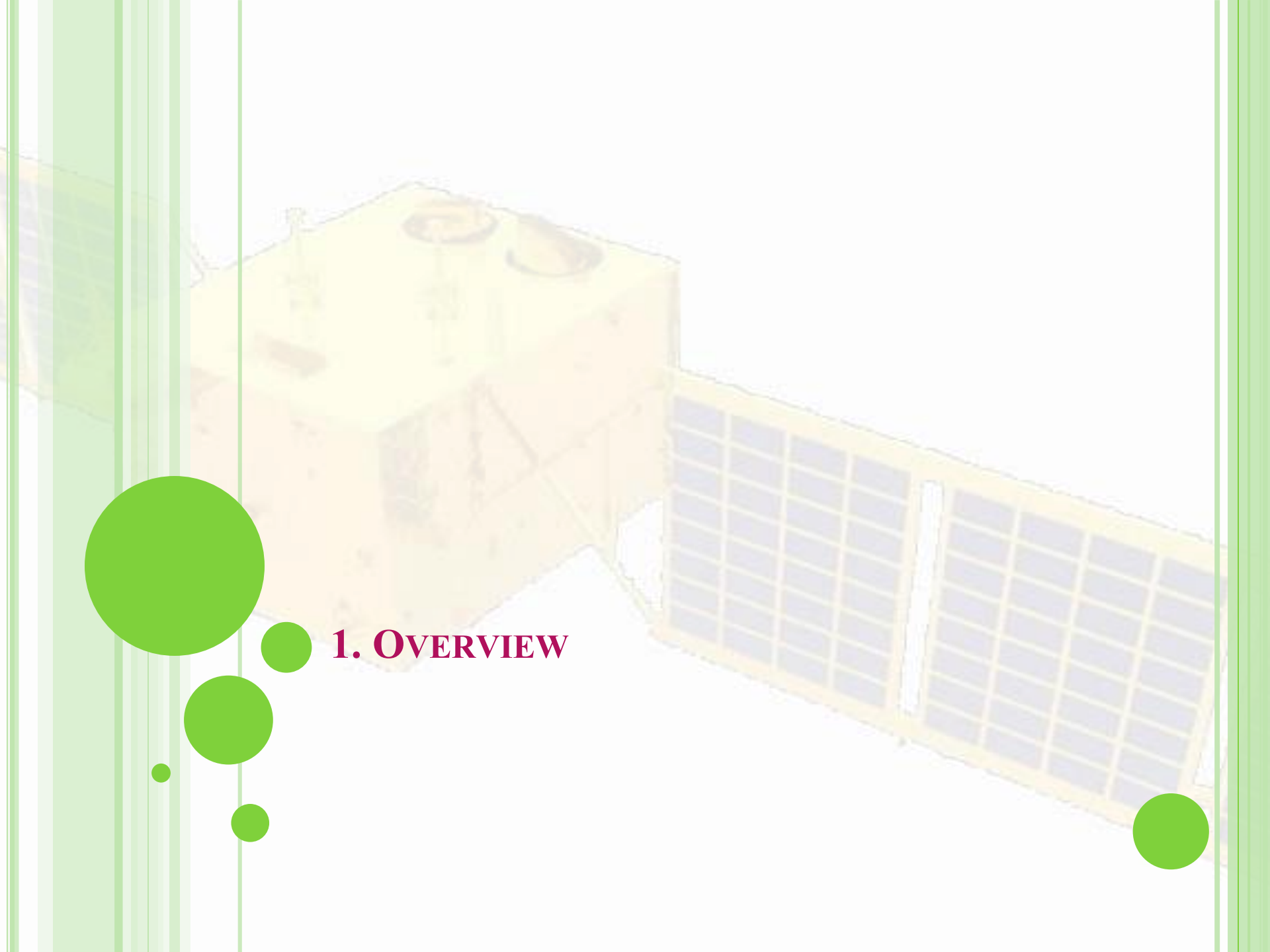
Outline

- Overview
- Previous work
- Current work—Model improvement
- Future work
- Plan towards final achievements



1. Overview

Goal

- GEO-IR rain estimate model for Thailand
  - High spatial/temporal resolution
  - Wide coverage area
- Near real-time rain monitoring for flood forecast

What we have?

- IR data from FY-2C/E satellite
- Rain gauge data from TMD over Chao Phraya basin 2009-2010
- GSMaP (near real-time (NRT))
- GSMaPnew (MVK v5)

Satellite data for rain estimation from DVB-S

Calibration & validation data from TMD

Reference models for comparison from JAXA/EORC

DATA

Data	Resolution	Source
Rain gauge data	70 stations over Chao Phraya basin Every 1 hour	TMD
DVB-S system	Country wide 5x5 km^2 Every 1 hour, Latency 1 hour	GEO satellite (IR) FY-2C/E
GSMaP (NRT)	Country wide 0.1x0.1 $degree^2$, ~11x11 km^2 Every 1 hour Latency ~4 hour	Combined GEO/LEO satellite + Ancillary Data GEO (IR): MTSAT, METSOSAT-7/8, GOES-11/12 LEO (Microwave): TRMM, AQUA, DMSP-F13-17
GSMaPnew	Country wide 0.1x0.1 $degree^2$, ~11x11 km^2 Every 1 hour Latency more than 4 hour (latest output on November, 2010)	Combined GEO/LEO satellite + Ancillary Data GEO (IR): MTSAT, METSOSAT-7-8, GOES-11-12 LEO (Microwave): TRMM, AQUA, ADEOS-II, DMSP-F11-17, NOAA-N15-19, MetOp-A

Ancillary Data:

JMA Global Analysis (GANAL) (numerical weather prediction (NWP))

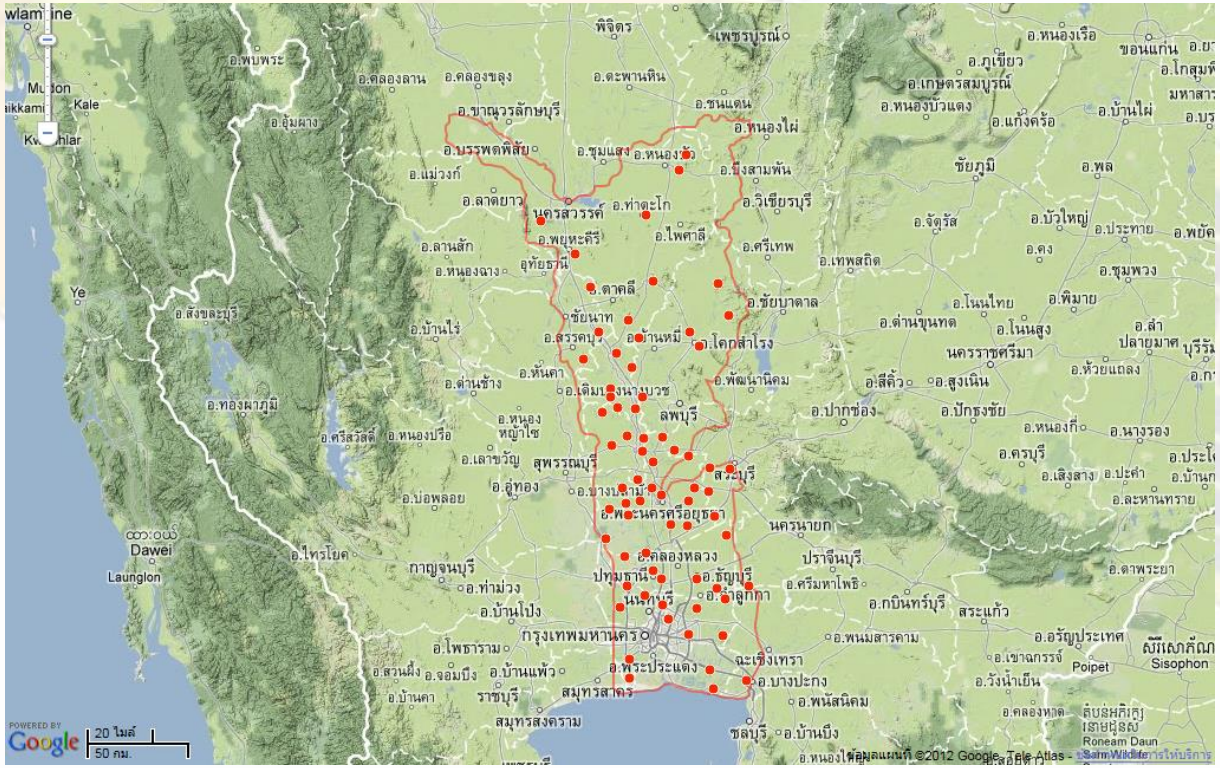
JMA Merged satellite and in situ data Global Daily Sea Surface Temperatures (MGDSST)

DIFFERENCE BETWEEN GSMAP NRT AND MVK

Item	GSMaP_NRT	GSMAP_MVK
Input data availability	Input data which is available within 3 hours from observation	All available data
Input data: GEO Infrared radiometer	Globally-merged pixel-resolution data by JWA	Globally-merged full-resolution data by NOAA/CPC
Look-up table for the GSMaP microwave imager algorithm	Calculate once a day at around 3UTC and use nearest GANAL and MGDSST as inputs	Calculate once a day (00UTC) and use nearest to observation time
Look-up table for the GSMaP microwave sounder algorithm	N/A	Calculate once a day (00UTC)
The GSMaP microwave–IR combined algorithm	A simplified version of the algorithm (morphing and Kalman filtering by forward process)	A full version of the algorithm (morphing and Kalman filtering by forward and backward processes)

Target area

- Chao Phraya basin
- Rain gauge data from TMD 70 stations



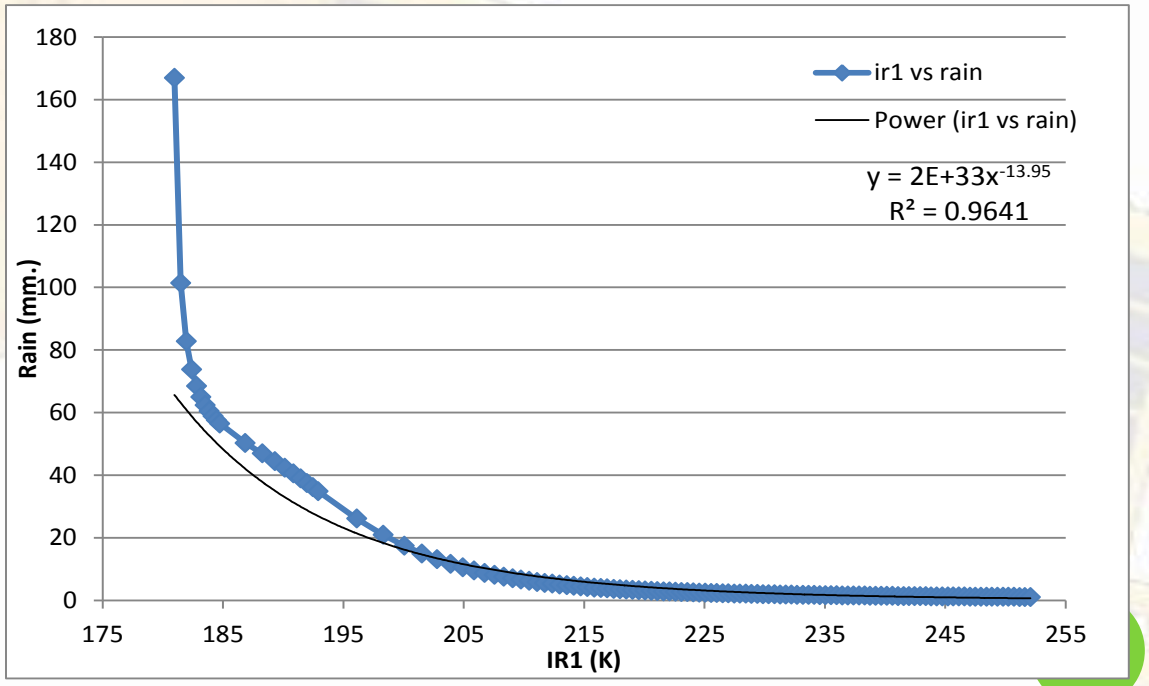
Overview summary

- Input data for our model is only IR image from FY-2C/E
- Rain gauge data is used for validation (Test the data on Chao Phraya basin)
- GSMaP and GSMaPnew are used as reference for comparing with our model, it's inputs are combined IR and microwave from many satellites

2. Previous Work

ITR Model

- Create Model from data May to October 2009.
- Decision:
  - IR1<253K
- Estimate:
  - Probability matching



RESULT SKILL SCORE

hourly	Gsmap_nrt	gsmapnew	2009m5m10itr
hit_count	11341	24262	19713
false_alarm_count	53963	95664	127064
miss_count	21524	8401	10069
correct neg. count	975767	889628	750988
Accuracy	0.9290	0.8978	0.8489
Bias	1.9870	3.6716	4.9284
POD	0.3451	0.7428	0.6619
FAR	0.8263	0.7977	0.8657
POFD	0.0524	0.0971	0.1447
ETS	0.1099	0.1640	0.0980
hits_random	2019.7874	3848.0512	4815.1012
HK	0.2927	0.6457	0.5172
Mean rain truth	0.1093	0.1134	0.1164
Mean rain data	0.1070	0.1709	0.5236
RMSE	1.4488	1.4296	2.4948
Correlation	0.0900	0.2429	0.1590

daily	Gsmap_nrt	gsmapnew	2009m5m10itr
hit_count	7544	9514	9163
false_alarm_count	7548	10388	11677
miss_count	3065	989	1064
correct neg. count	26189	21595	18479
Accuracy	0.7607	0.7322	0.6845
Bias	1.4226	1.8949	2.0377
POD	0.7111	0.9058	0.8960
FAR	0.5001	0.5220	0.5603
POFD	0.2237	0.3248	0.3872
ETS	0.2704	0.2876	0.2337
hits_random	3610.4954	4919.9903	5277.7327
HK	0.4874	0.5810	0.5087
Mean rain truth	2.6196	2.7177	2.7993
Mean rain data	2.5634	4.0945	12.3507
RMSE	10.0720	9.4172	24.6562
Correlation	0.2949	0.4952	0.3638

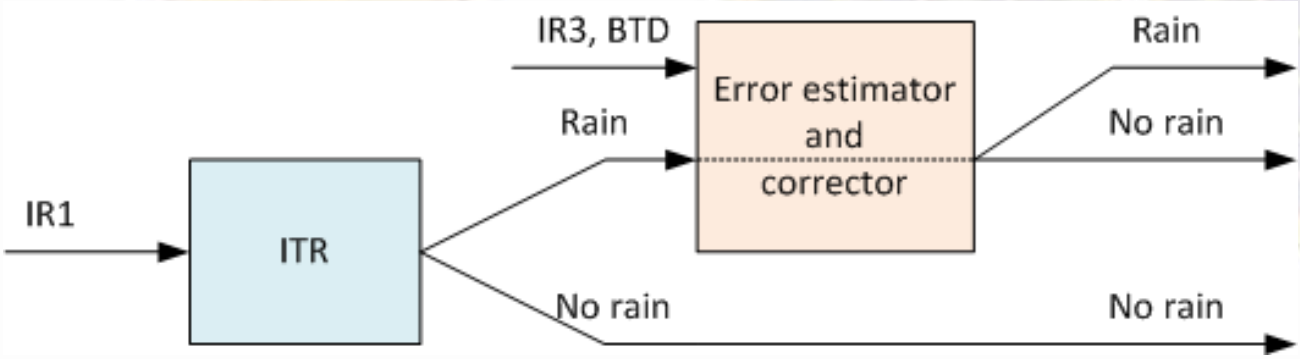
Previous Work Summary

- GSMaPnew is the best score. (improve POD, FAR, ETS,RMSE from GSMaP_nrt)
- Compare ITR with GSMaP_nrt
  - ITR is better on POD (0.6619, 0.3451)
  - ITR is worse on FAR (0.8657, 0.8263)
  - ITR is little lower on ETS (0.0980, 0.1099)
  - ITR is worse on RMSE (2.4948, 1.4488)
- Try to improve our ITR model, target on improving RMSE

3. Model improvement

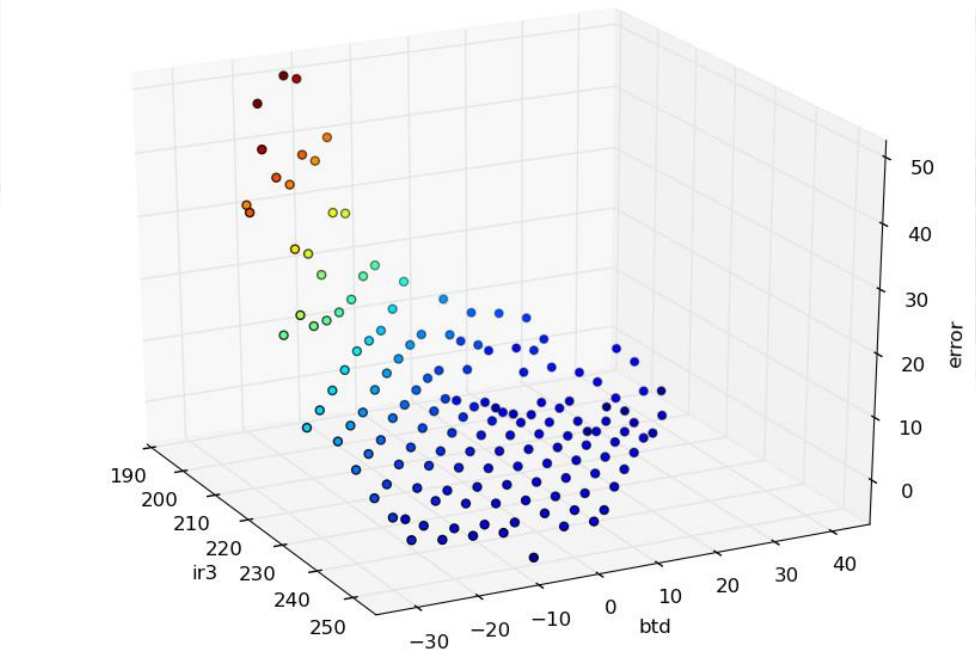
Error correction

- $Error = Rain_{ITR_model} - Rain_{gauge}$
- $Rain_{error_corrected} = Rain_{ITR_model} - Error_{estimated}$
- The model become error-corrected ITR **(called EC-ITR)**
- Estimate error from IR3 and BTD(IR1-IR3) given that ITR predicts rain (IR1<253K)



How to Estimate error

- Estimate the average error grouped by IR3 and BTD
  - Using Eureqa formulize which is a scientific data mining software package that searches for mathematical patterns hidden in data (http://formulize.nutonian.com/)
- Result: Estimated error = 732.7+0.3325*btd^2+0.02911*ir3*btd+0.01318*ir3^2+6.033e-6*ir3^2*btd^2-6.218*ir3-6.904*btd-0.002779*ir3*btd^2



Result skill score

- In hourly skill score, EC-ITR improves in ACC, POFD and RMSE but worsens in POD, FAR, ETS
- In daily skill score, EC-ITR worsens only in POD but improves in ACC, RMSE, FAR, POFD, ETS
- EC-ITR's RMSE is very close to that of GSMaP's

hourly	gsmap	gsmapnew	2009m5m10itr	itr_error_corrected
hit_count	11341	24262	19713	13913
false_alarm_count	53963	95664	127064	94027
miss_count	21524	8401	10069	15869
correct neg. count	975767	889628	750988	784025
Accuracy	0.9290	0.8978	0.8489	0.8789
Bias	1.9870	3.6716	4.9284	3.6243
POD	0.3451	0.7428	0.6619	0.4672
FAR	0.8263	0.7977	0.8657	0.8711
POFD	0.0524	0.0971	0.1447	0.1071
ETS	0.1099	0.1640	0.0980	0.0862
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hit_count	7544	9514	9163	8870
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correct neg. count	26189	21595	18479	19479
Accuracy	0.7607	0.7322	0.6845	0.7020
Bias	1.4226	1.8949	2.0377	1.9113
POD	0.7111	0.9058	0.8960	0.8673
FAR	0.5001	0.5220	0.5603	0.5462
POFD	0.2237	0.3248	0.3872	0.3541
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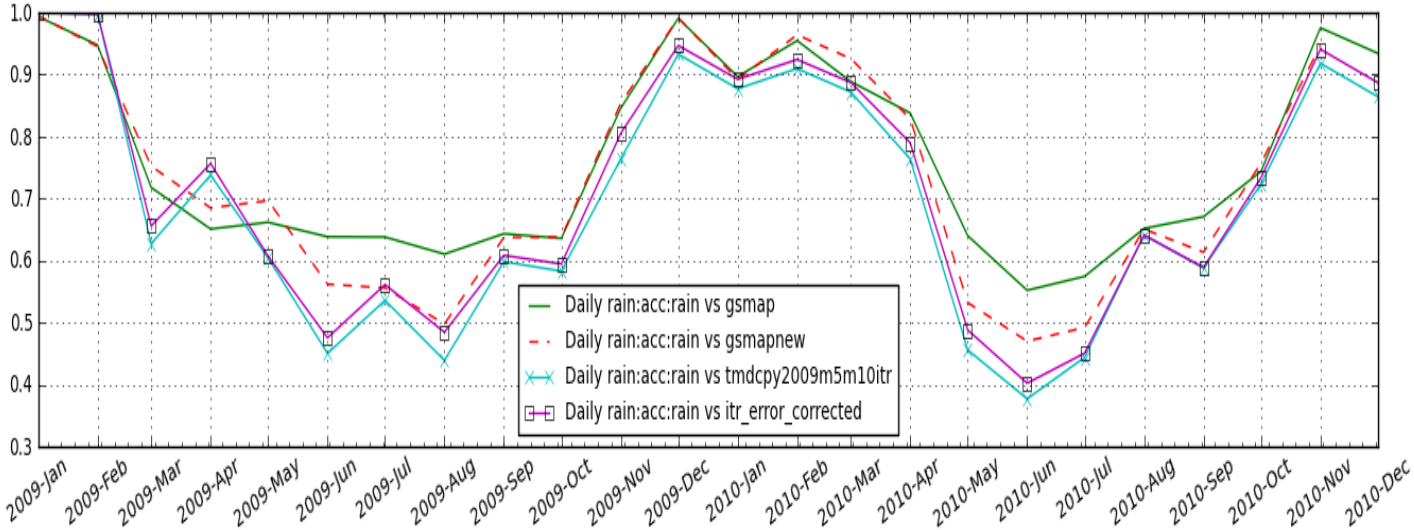
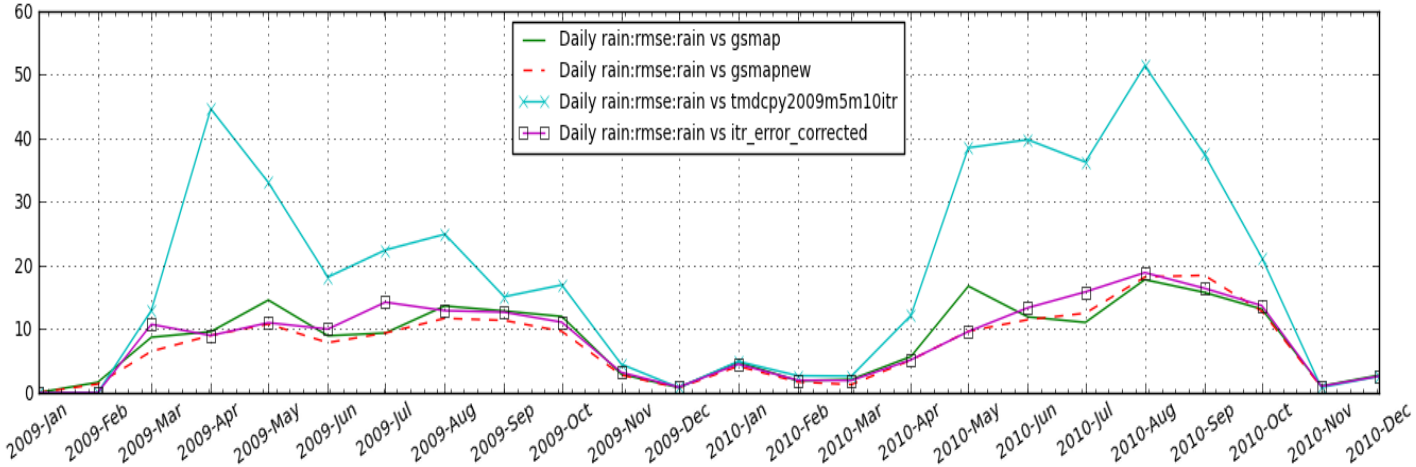
hits_random	3610.4954	4919.9903	5277.7327	4950.2803
HK	0.4874	0.5810	0.5087	0.5133
Mean rain truth	2.6196	2.7177	2.7993	2.7993
Mean rain data	2.5634	4.0945	12.3507	5.2770
RMSE	10.0720	9.4172	24.6562	10.4089
Correlation	0.2949	0.4952	0.3638	0.3355

Daily score group by month (1)

Accuracy

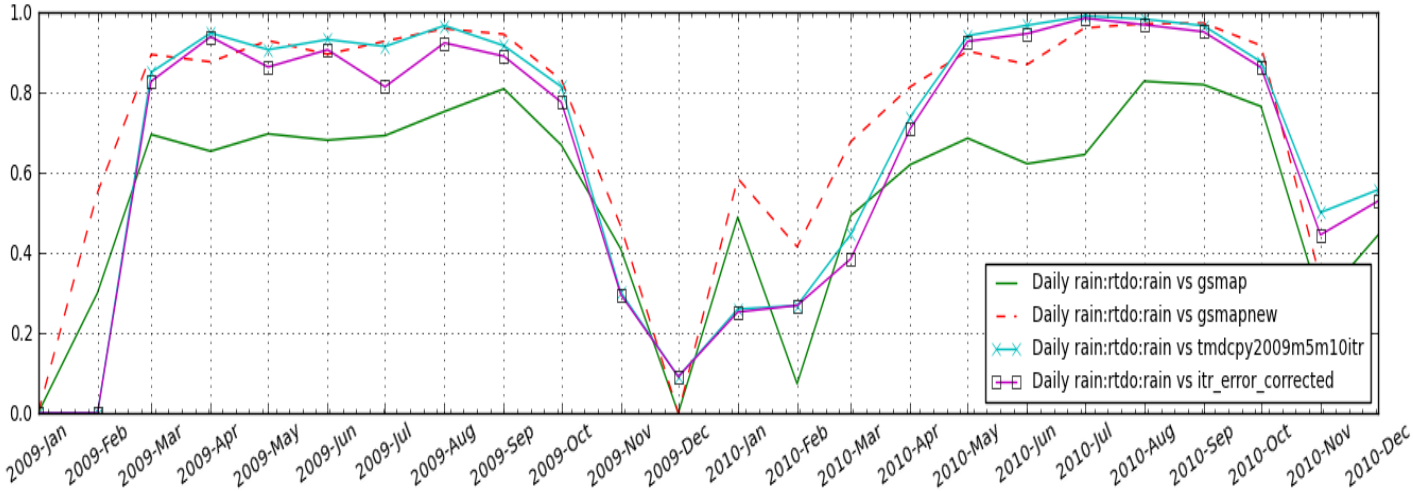


RMSE

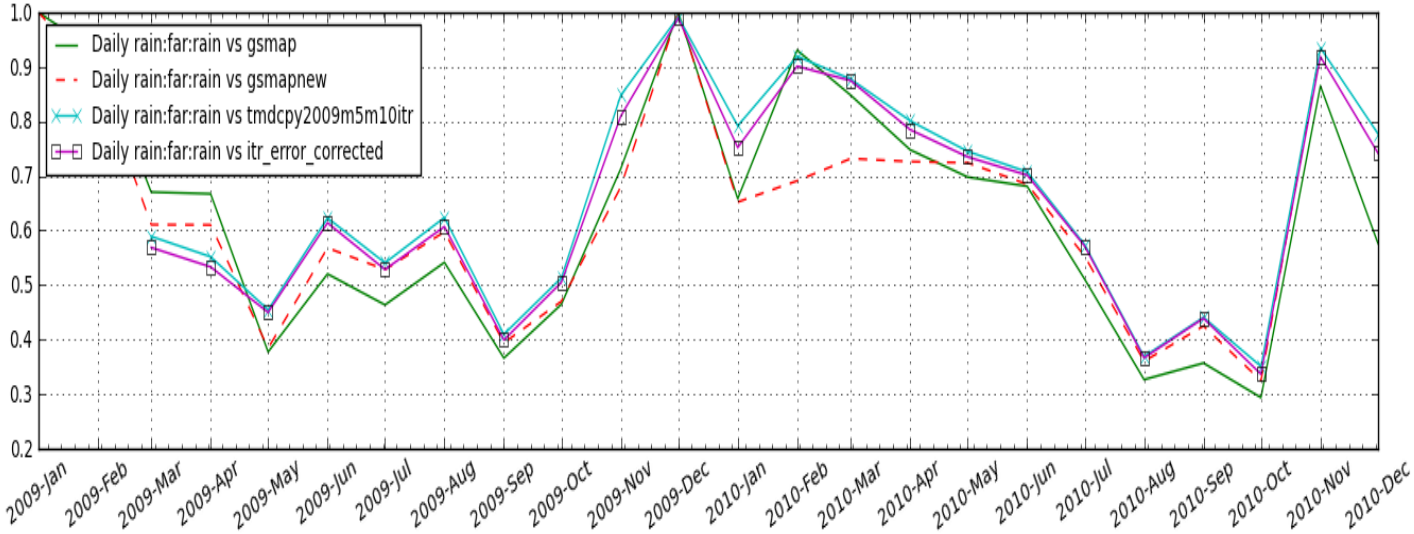


Daily score group by month (2)

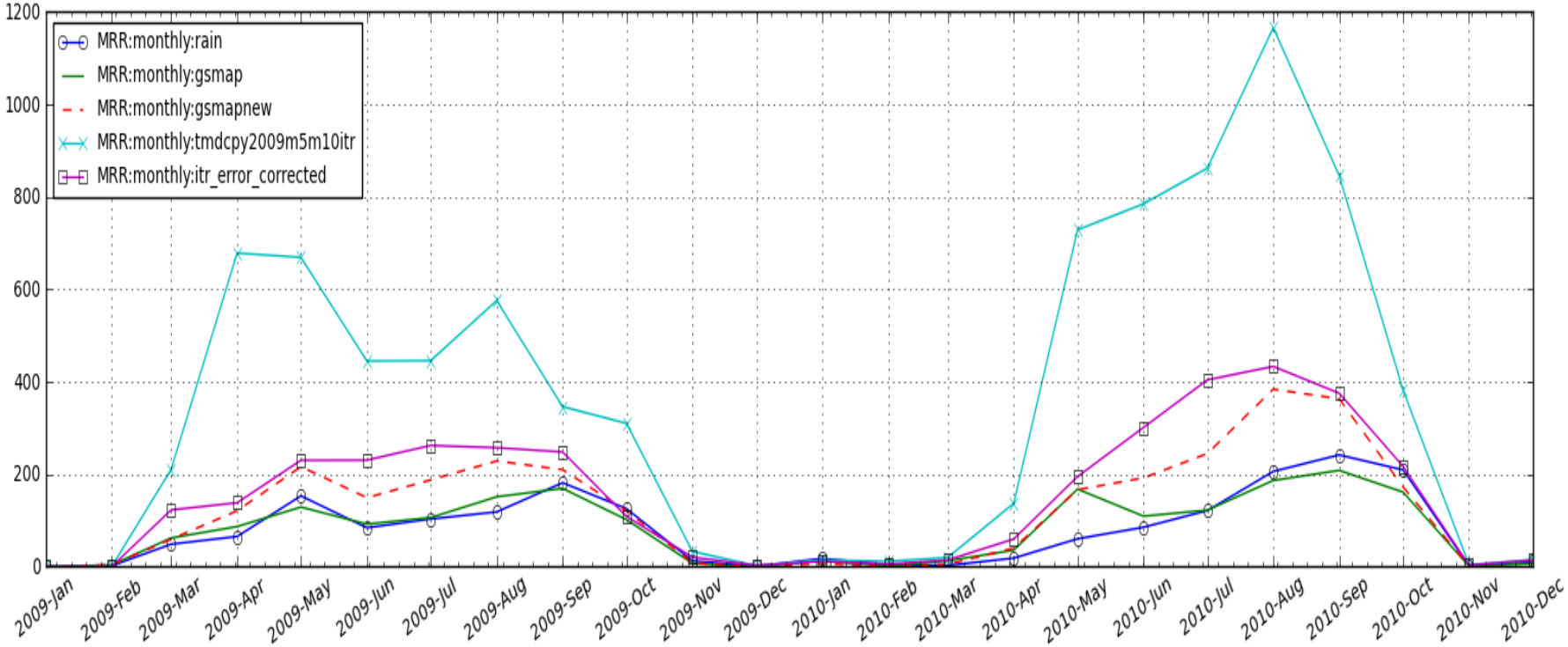
POD



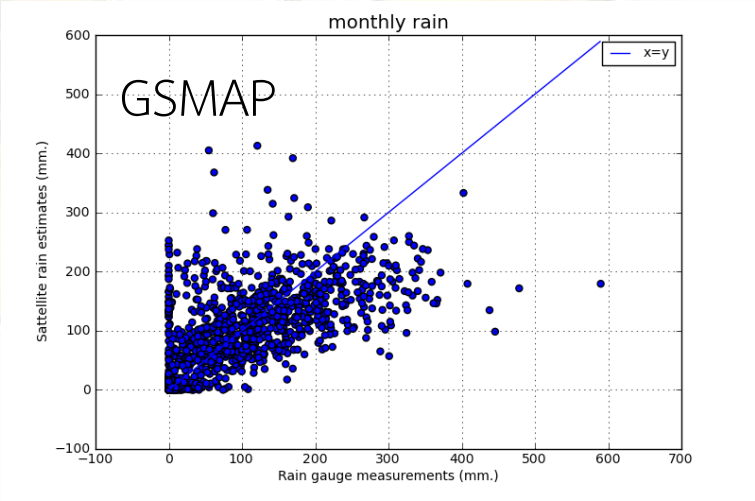
FAR

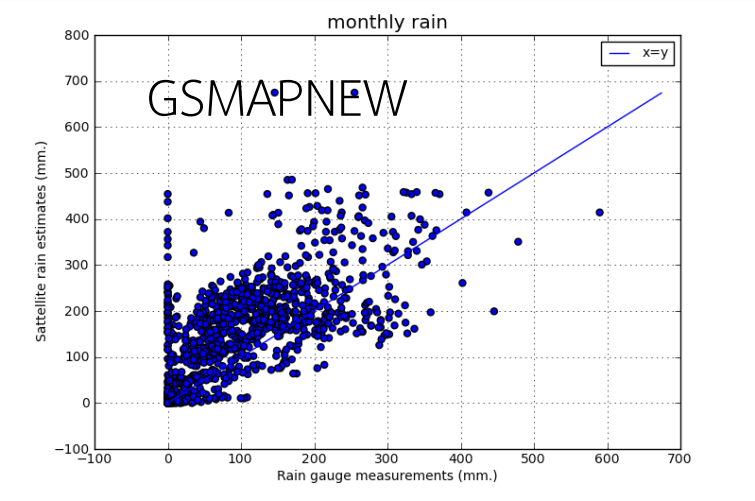


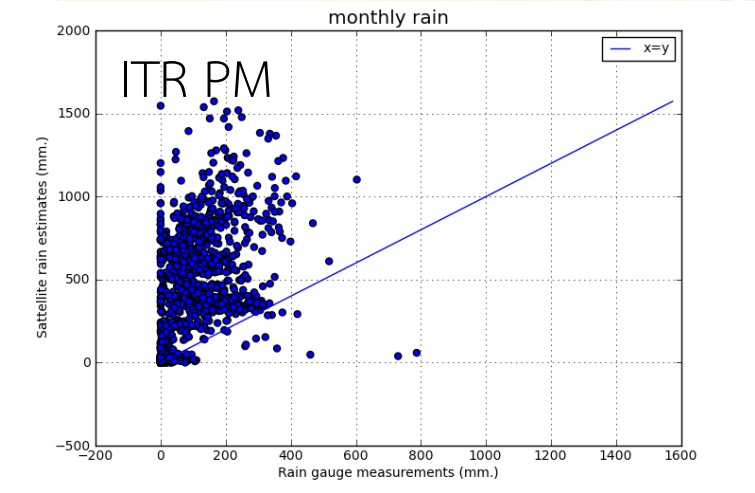
Monthly Mean Rain

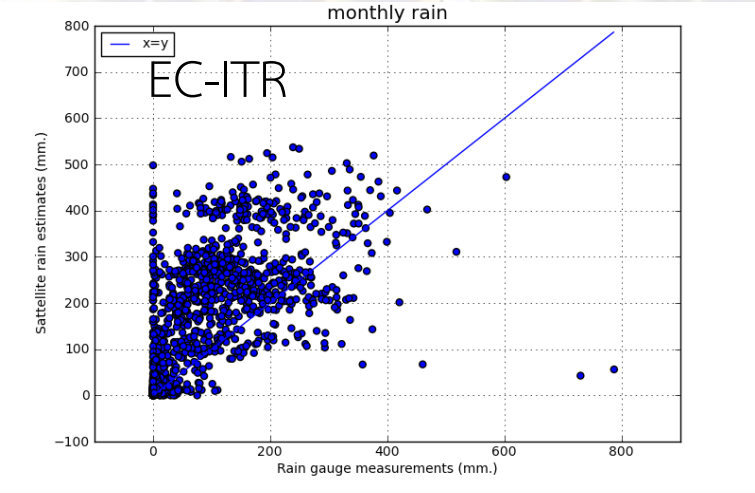


Monthly scatter plot









Model improvement summary

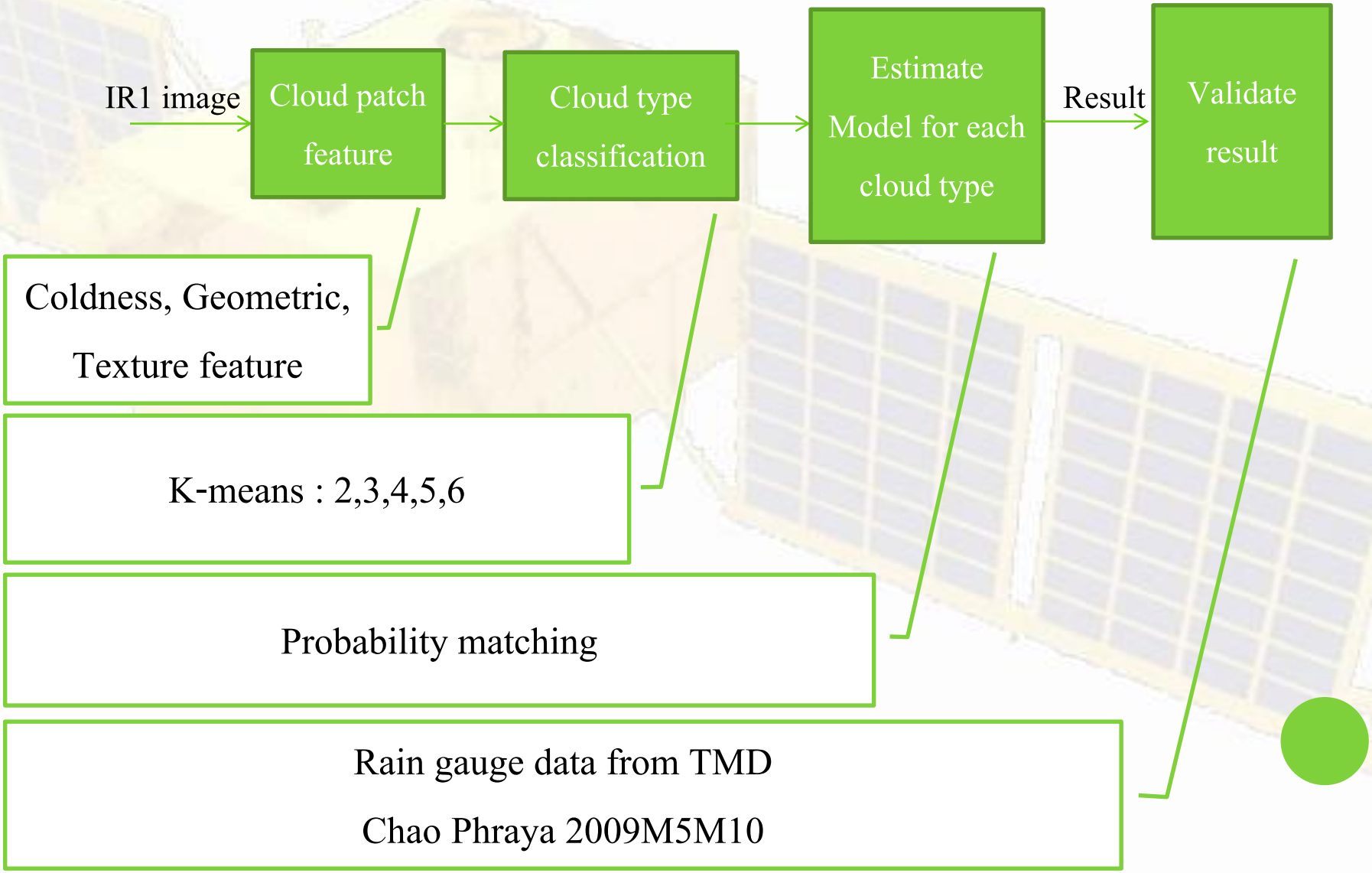
- EC-ITR is better in daily skill score (lose only POD, improve ACC, RMSE, FAR, POFD, ETS)
- EC-ITR improve significantly in rain amount (improve RMSE and monthly mean rain)
- Considering its simple requirement (only GEO-IR data) and near-realtime prediction (1-hour latency), EC-ITR is a viable alternative to GsMAP_nrt (GsMAP_new is not currently available up-to-date).

4. Future work

Overview future work

- Basic concept
  - Each cloud type has different rain intensity
- Target
  - Improve model by using cloud type classification
    - Cloud type classification by cloud patch feature technique
    - Cloud type classification by Neural network (TRMM for training)

Research Work Flow: Cloud type classification by cloud patch feature technique



Cloud patch features

- Coldness features of cloud patch
  1. IR1 min
  2. IR1 mean
- Geometric features
  3. Area
  4. Shape index
- Texture feature
  5. Std dev (Standard deviation)
  6. Mean of local std dev 5x5
  7. Std dev of local std dev 5x5
  8. Temperature gradient of cloud cold core
  9. MASM (Gray level co-occurrence)

Cloud type classification

- Use K-means to classify cloud type
  - Test 2, 3, 4, 5, 6 type

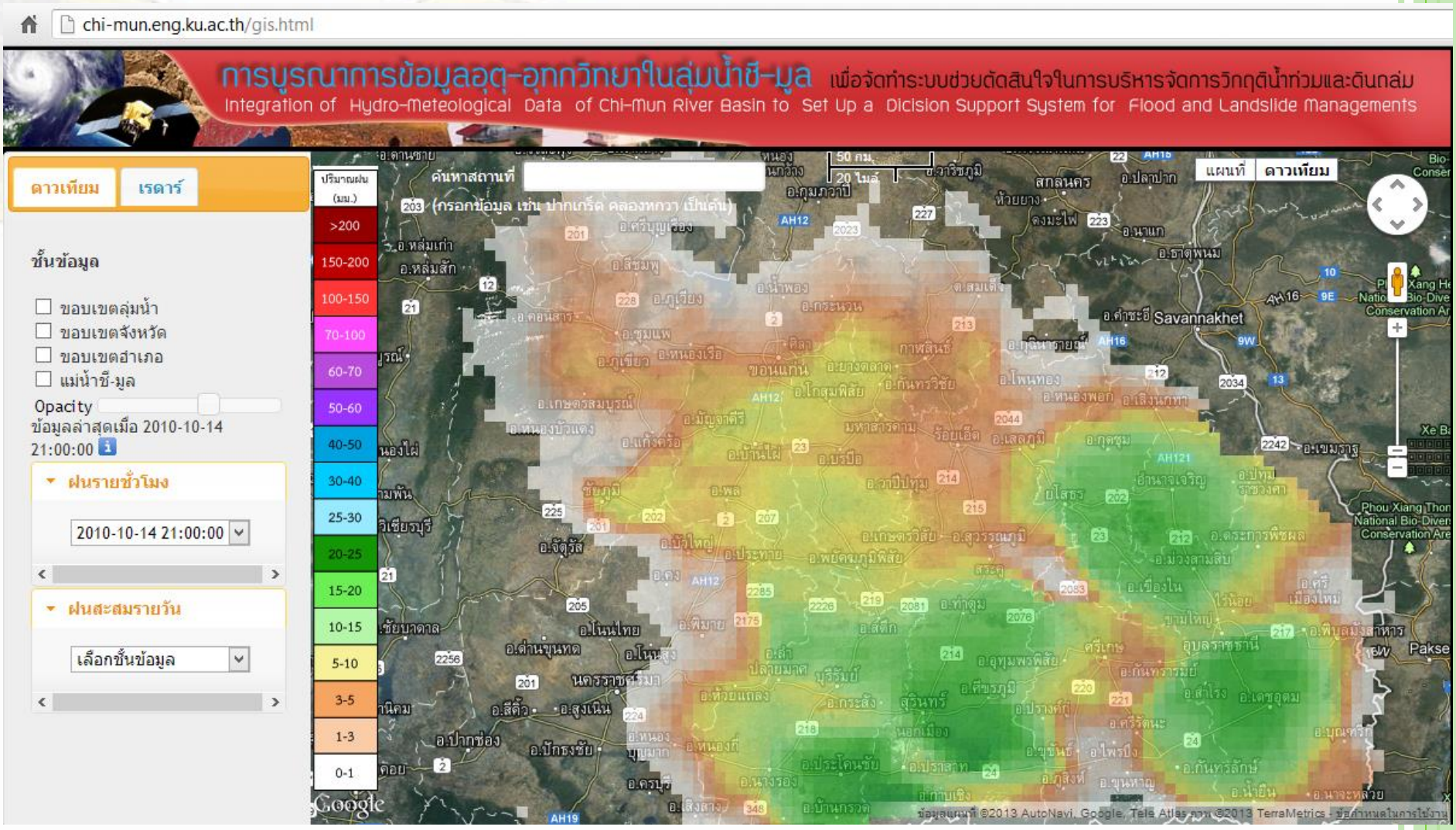
Future work summary

- Try to improve the model by using cloud type classification.
- We may use cloud patch feature or using TRMM data to classify the cloud types.

Plan Towards Final Achievement

- Final achievement—to put the model into operation.
- Plan
  - Develop a GIS-based web data service to publish the rain estimation from the model (hourly/daily) in the target area.
    - Data format: GeoTIFF
    - Latency 1 hour
    - Service availability 24/7
    - Trial 2Q13, Full Operation 3Q13 (Rainy season)

Sample Website from Related Project



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