Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates

Robert Adler, Weixin Xu
and Nai-Yu Wang
CICS/University of Maryland

A combination of existing project under Wang dealing with microwave/lightning relations and new proposal by Adler on IR/lightning rain estimation, both focused on improving GOES-R Baseline rain algorithm (Kuligkowski).

2 journal papers recently submitted

Xu, W., R. F. Adler, and N.-Y. Wang, 2012: Improving Geostationary Satellite Rainfall Estimates Using Lightning Observations, I: Underlying Lightning-Rainfall Relationships. *J. Appl. Meteor. Climatol., (*submitted).

Wang, N-Y, K. Gopalan, and R. Albrecht, 2012: Lightning, radar reflectivity and passive microwave observations over land from TRMM: Characteristics and application in rainfall retrievals, *J. Geophysical Research* (submitted).

Issues and Motivation

Limitations of infrared-based rain estimates:

-- Only "see" the top of precipitating cloud;
(though cloud growth or structure can be considered)

-- May treat cold cirrus clouds as intense convection;

-- May misrepresent convective rain: location, area and rain intensity;
(especially under relatively uniform cold cloud shields in mature MCSs)

(but geostationary rain estimation still very important because of temporal resolution and rapid access)

How would lightning information help?

-- Provide information associated with convection location and intensity (~ rainfall rate)

Objectives

Design a lightning-enhanced geostationary IR technique to

Remove false IR-defined intense convection

Identify convective cores and conv. rain area below cloud shields

Define correct rain intensity (on pixel scale)

Improve microwave-based calibration of IR technique

Recent Work/Approach

Examine lightning-cloud-rain relations with TRMM observations (papers submitted)

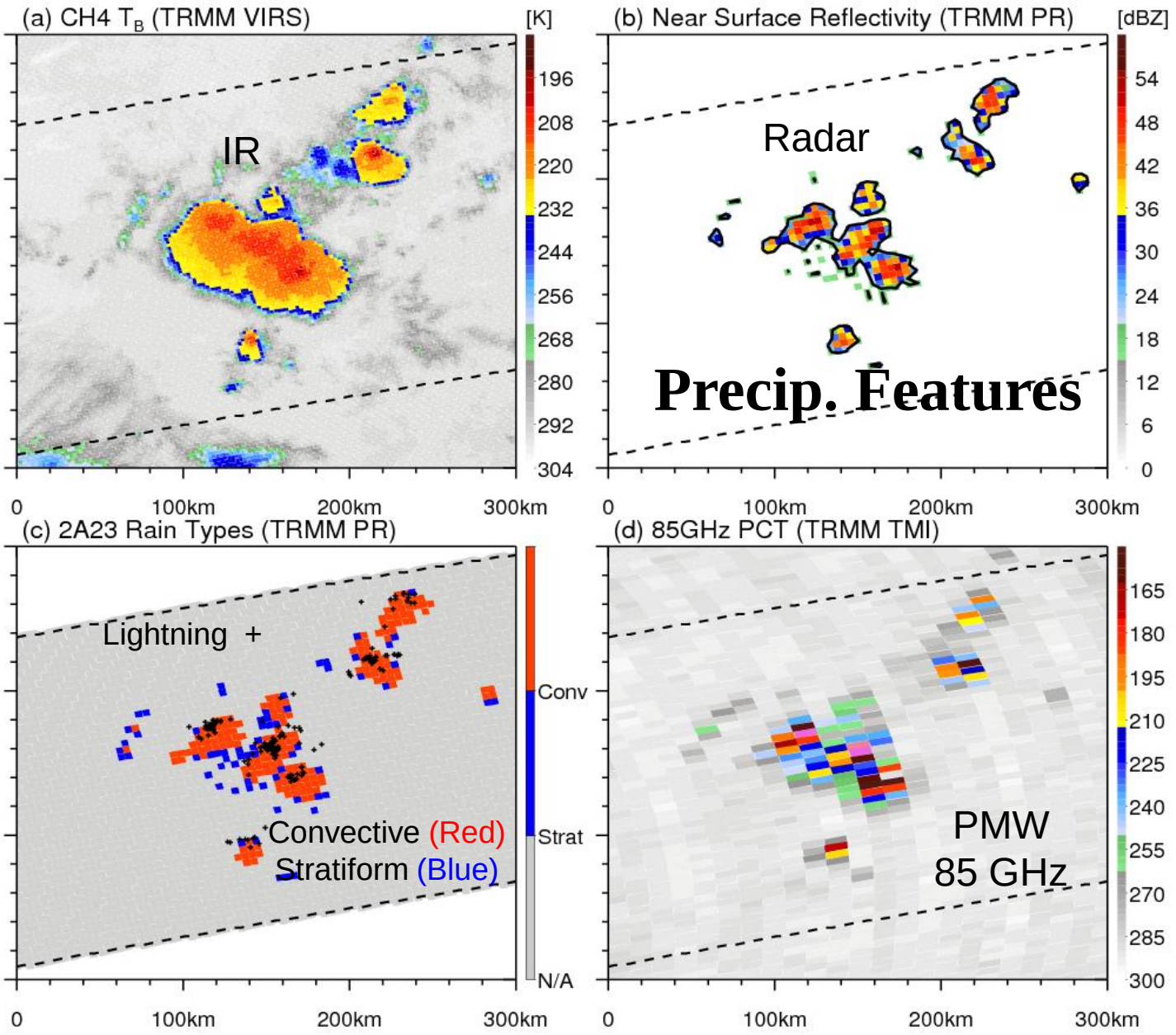
Develop a rain estimation technique to take advantage of lightning information potential—apply to TRMM data

Compare to Baseline algorithm

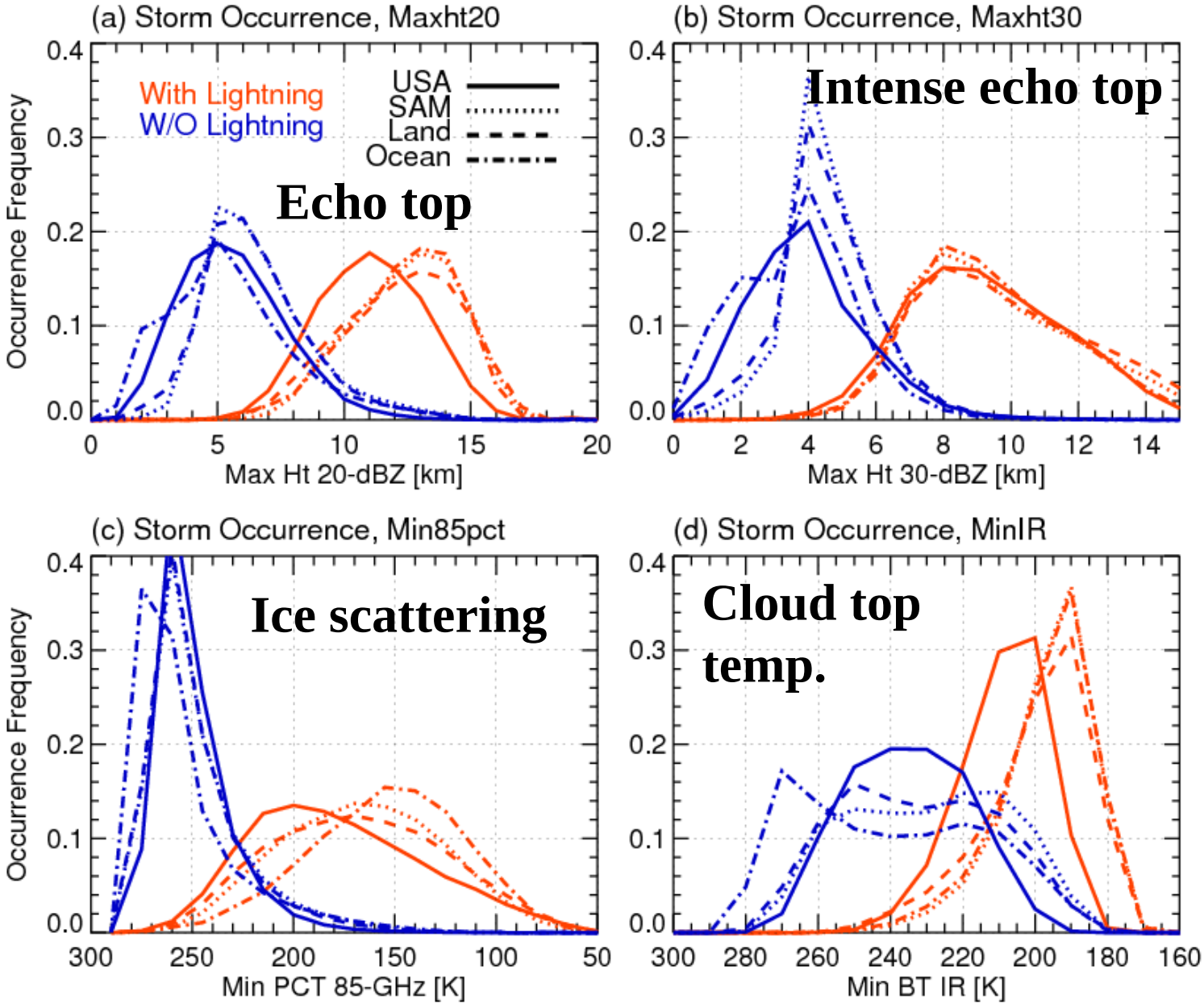
Relationships between Lightning and Convective Rainfall

Precipitation Features (radar raining clusters)

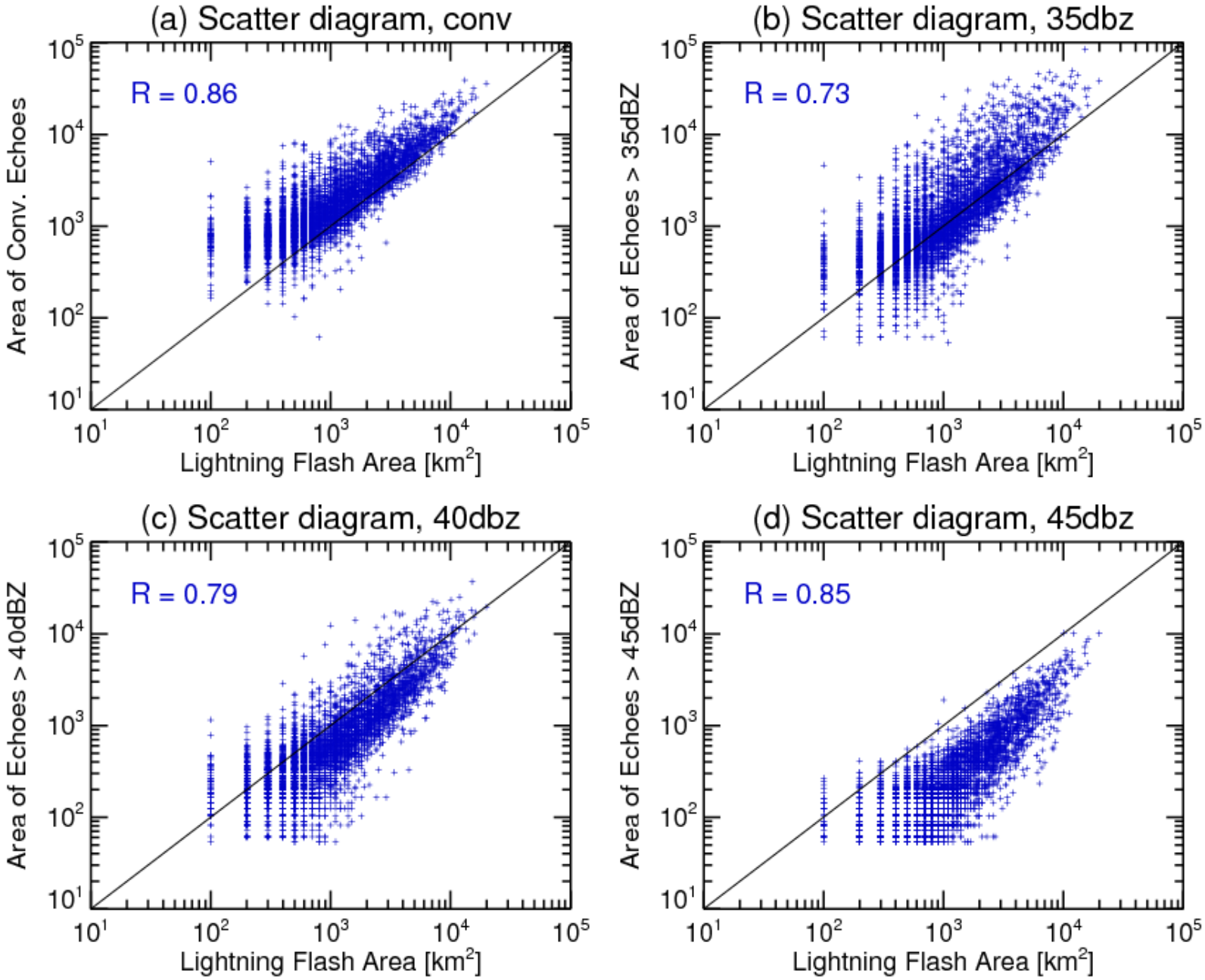
From University of Utah TRMM Precipitation Feature (PF) Database



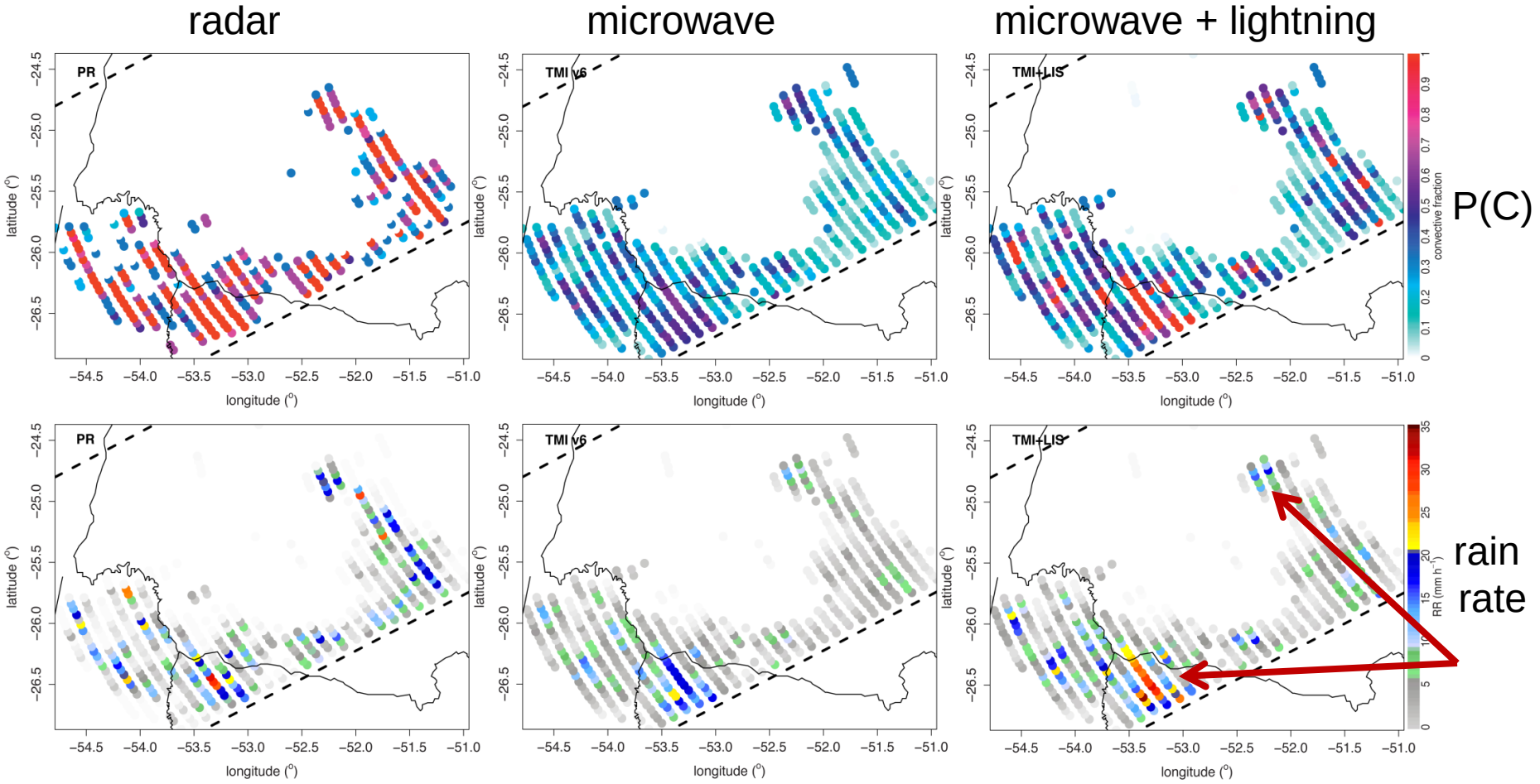
Storm discrimination by lightning



Defining Conv. Area (by lightning flash area)



Improvement of Passive Microwave Retrievals (Used as Calibrator for IR Baseline Algorithm) An Example: Lightning Impact on Rain Rate Retrievals



Overall impact of of lightning on rainrate is 5-10%, but focused on highest rainrates

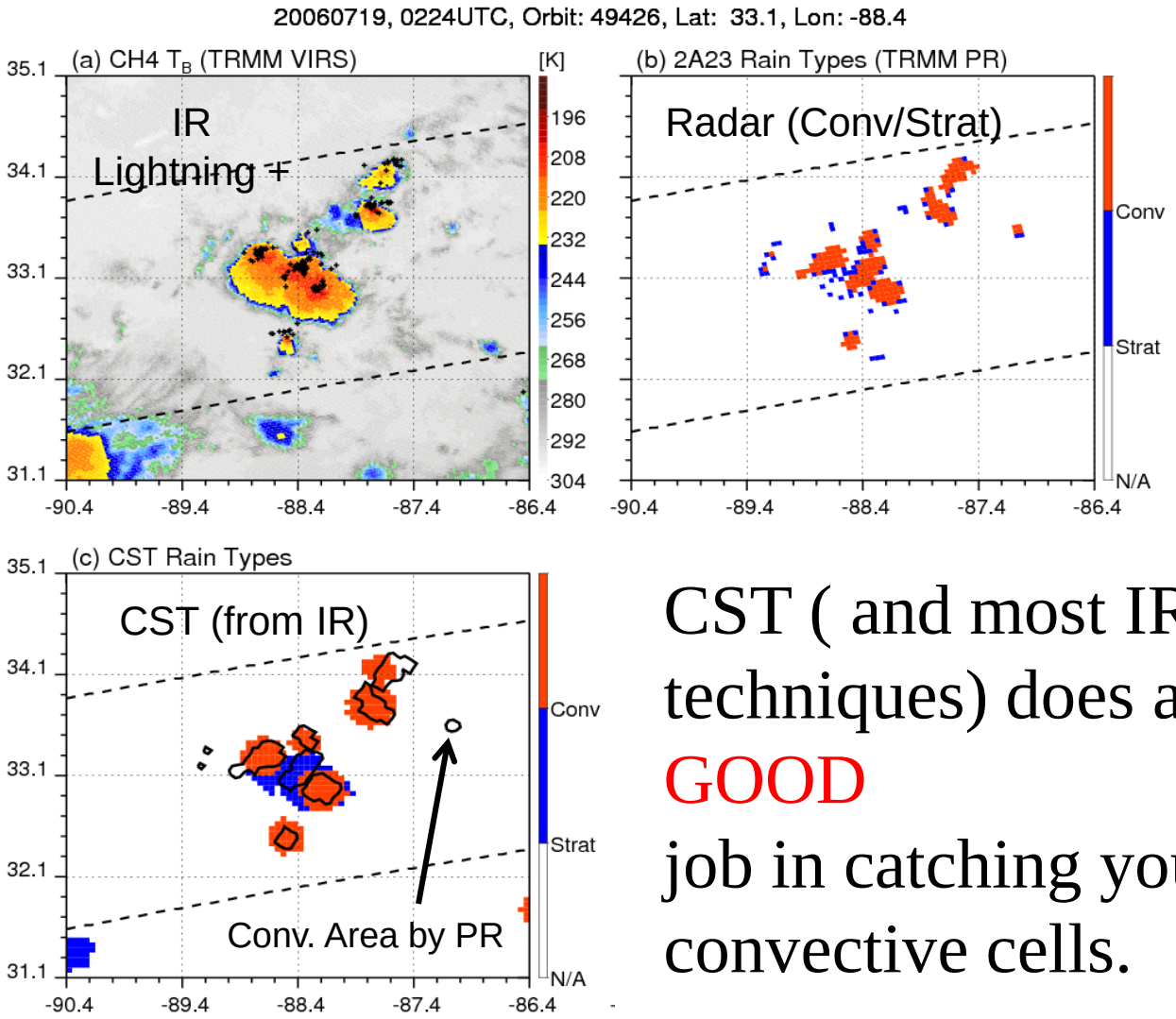
IR (and IR + Lightning) Rain Estimation Applied to TRMM Data

- Initial IR technique is variation of Convective Stratiform Technique (CST, Adler and Negri, 1988)
- Defines convective core/areas by IR T_b minima (with some tests) and stratiform rain area by T_b threshold (usually cold ~215K). Rain rates in convective and stratiform areas derived separately and empirically
- Lightning information will be used to define convective cores "unseen" by IR and eliminate IR cloud top minima incorrectly identified as "convective"

IR-based C/S Technique (CST)

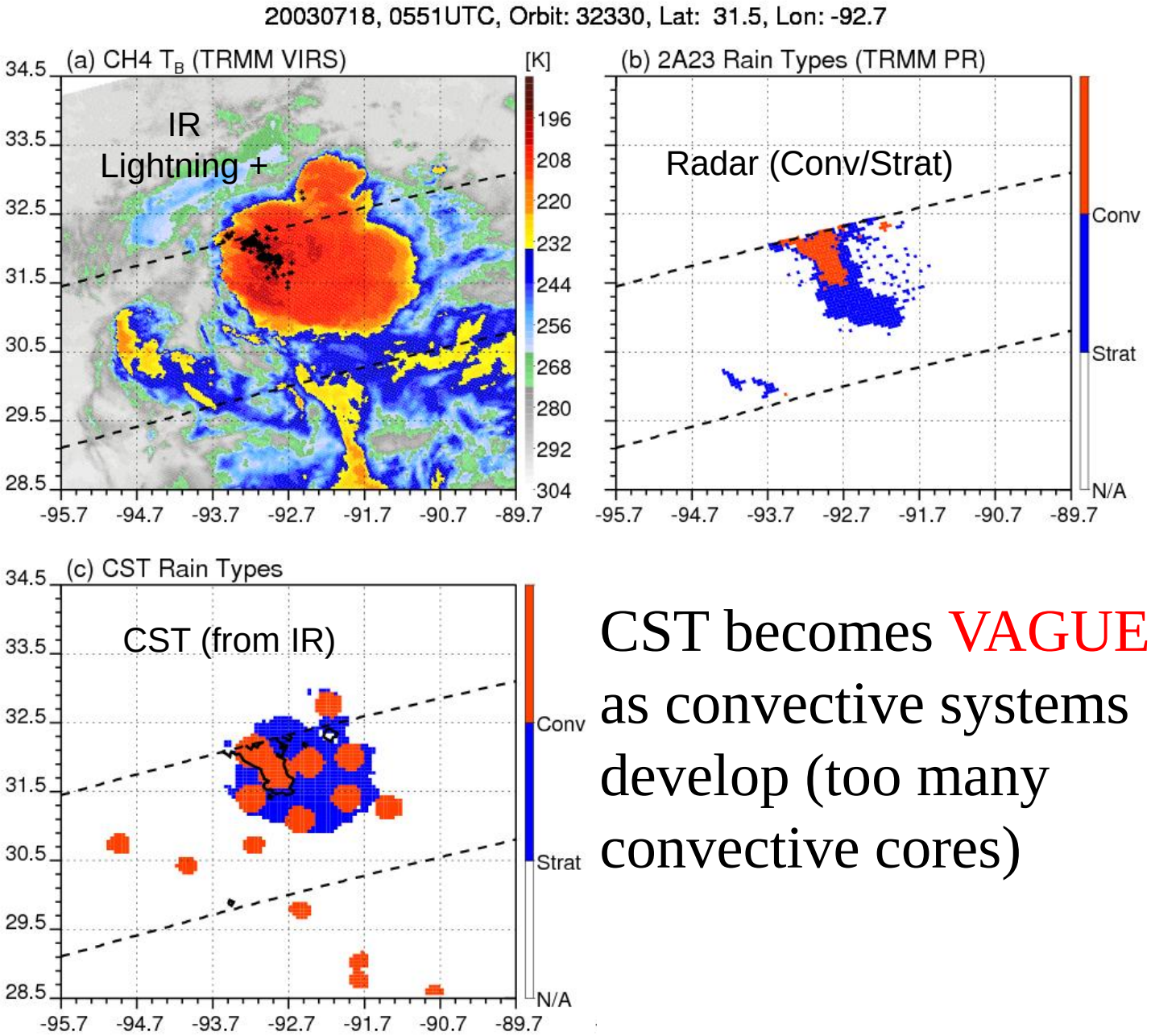
STEPS: (Adler and Negri, 1988)

1. Local Tb minima; 2. Slope test;



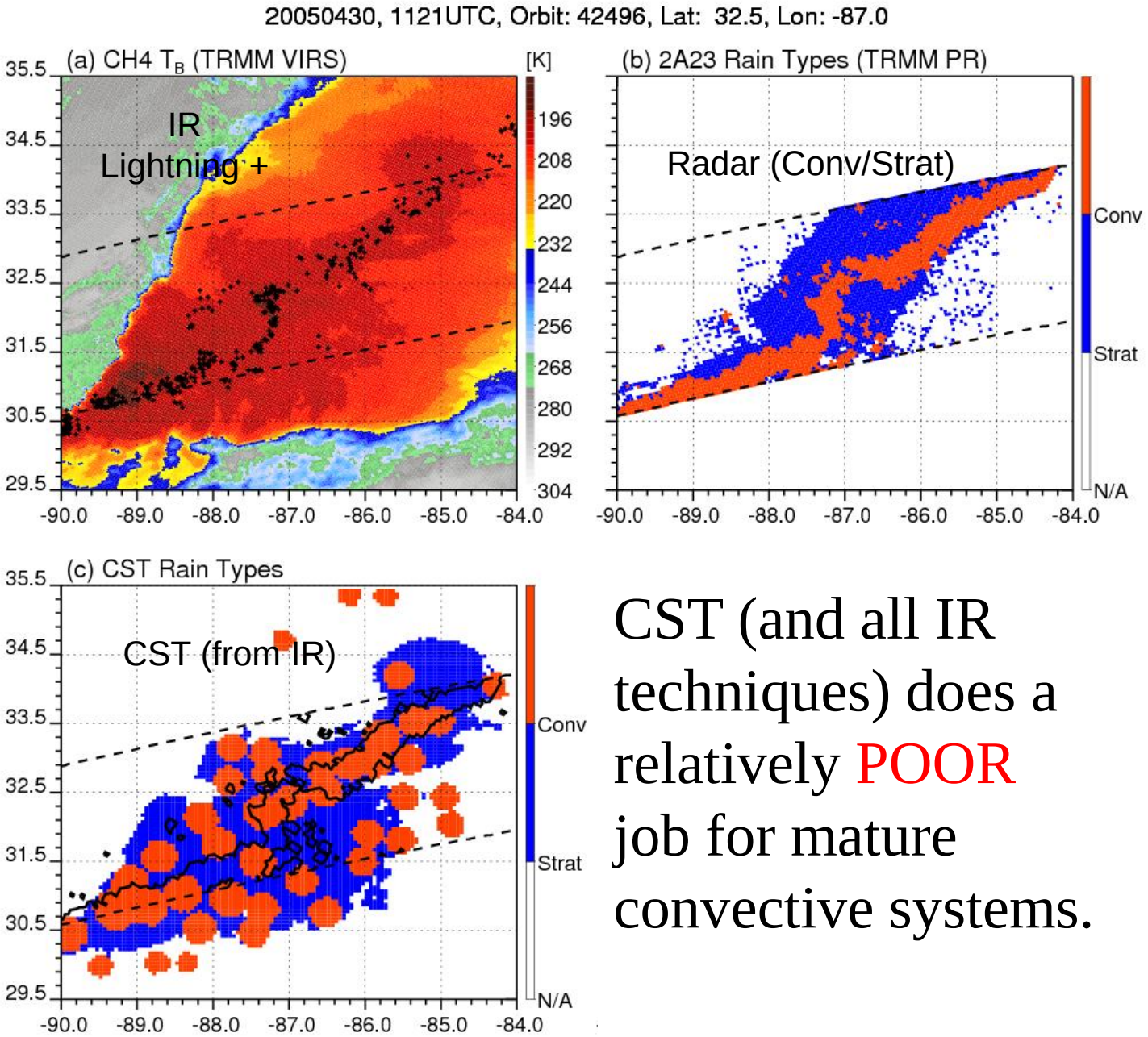
CST (and most IR techniques) does a GOOD job in catching young convective cells.

IR-based C/S Technique (CST)



CST becomes VAGUE as convective systems develop (too many convective cores)

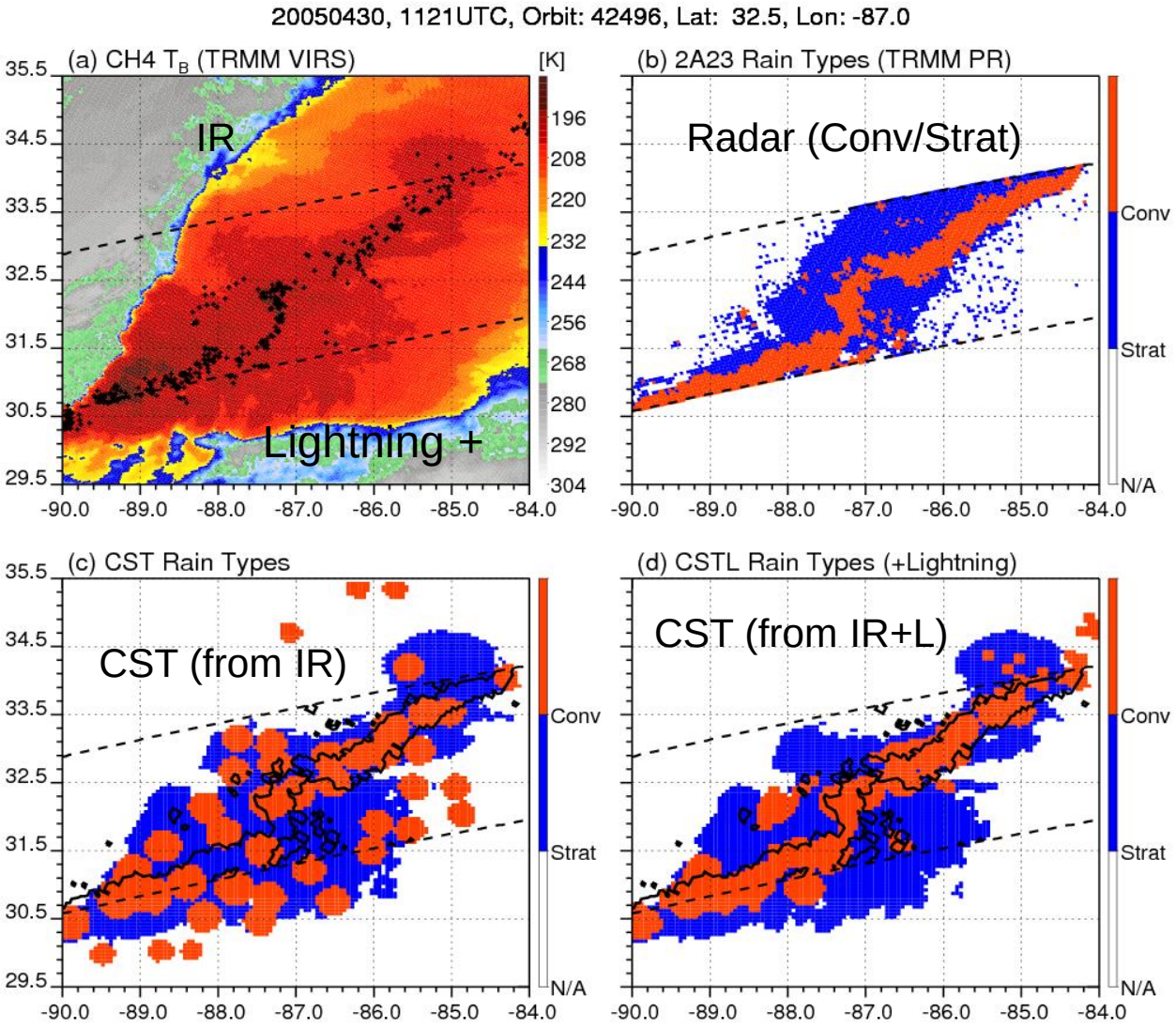
IR-based C/S Technique (CST)



CST (and all IR techniques) does a relatively POOR job for mature convective systems.

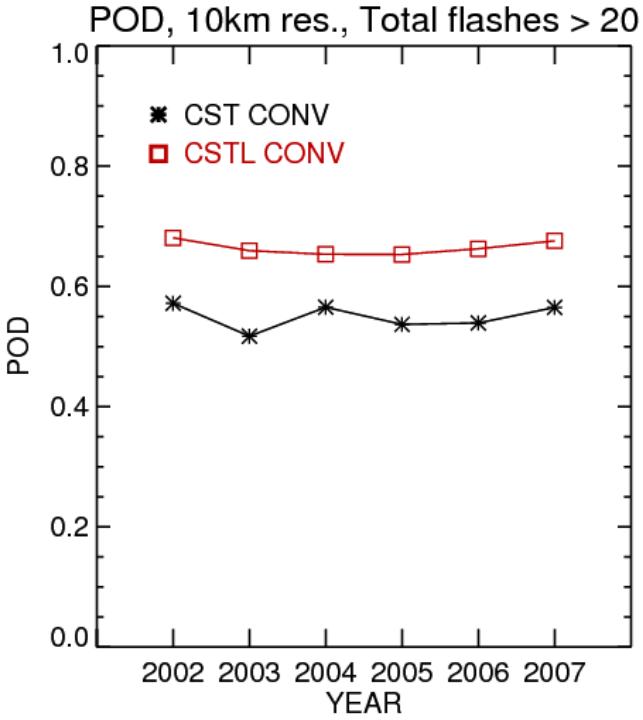
IR-Lighting-Combined C/S Technique (CSTL)

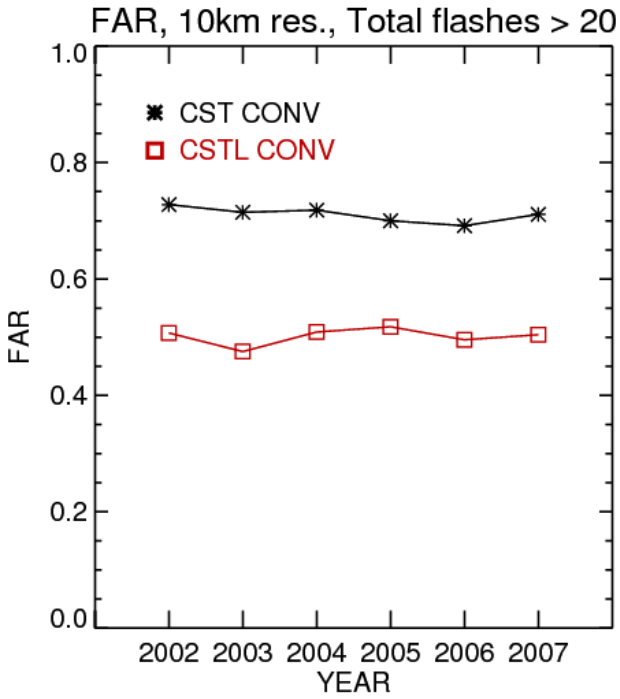
1. Conv. cores w/o lightning in mature systems are removed
2. Conv. areas (with flash) missed by CST are added;

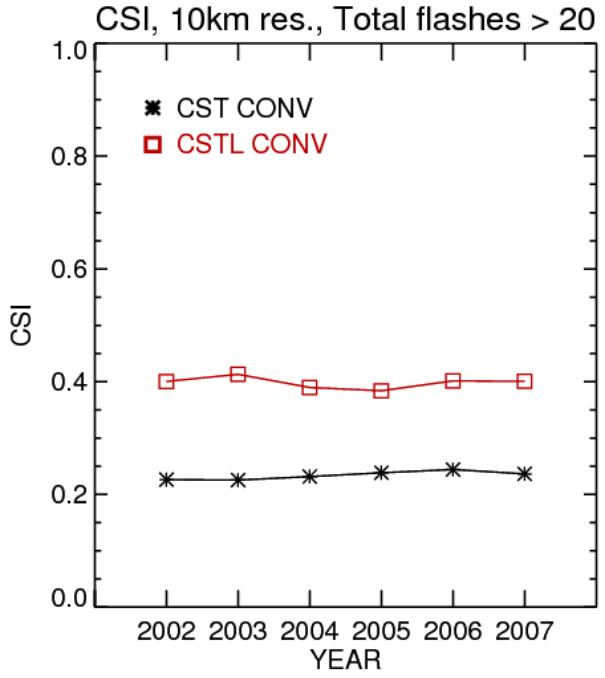


Identification of Convective Cores by Adding Lightning

* Estimates of Convective ID evaluated by PR;
* CST and CSTL run in an area (600x600 km^2);
* 2000 cases (> 20 lightning flashes) are selected;



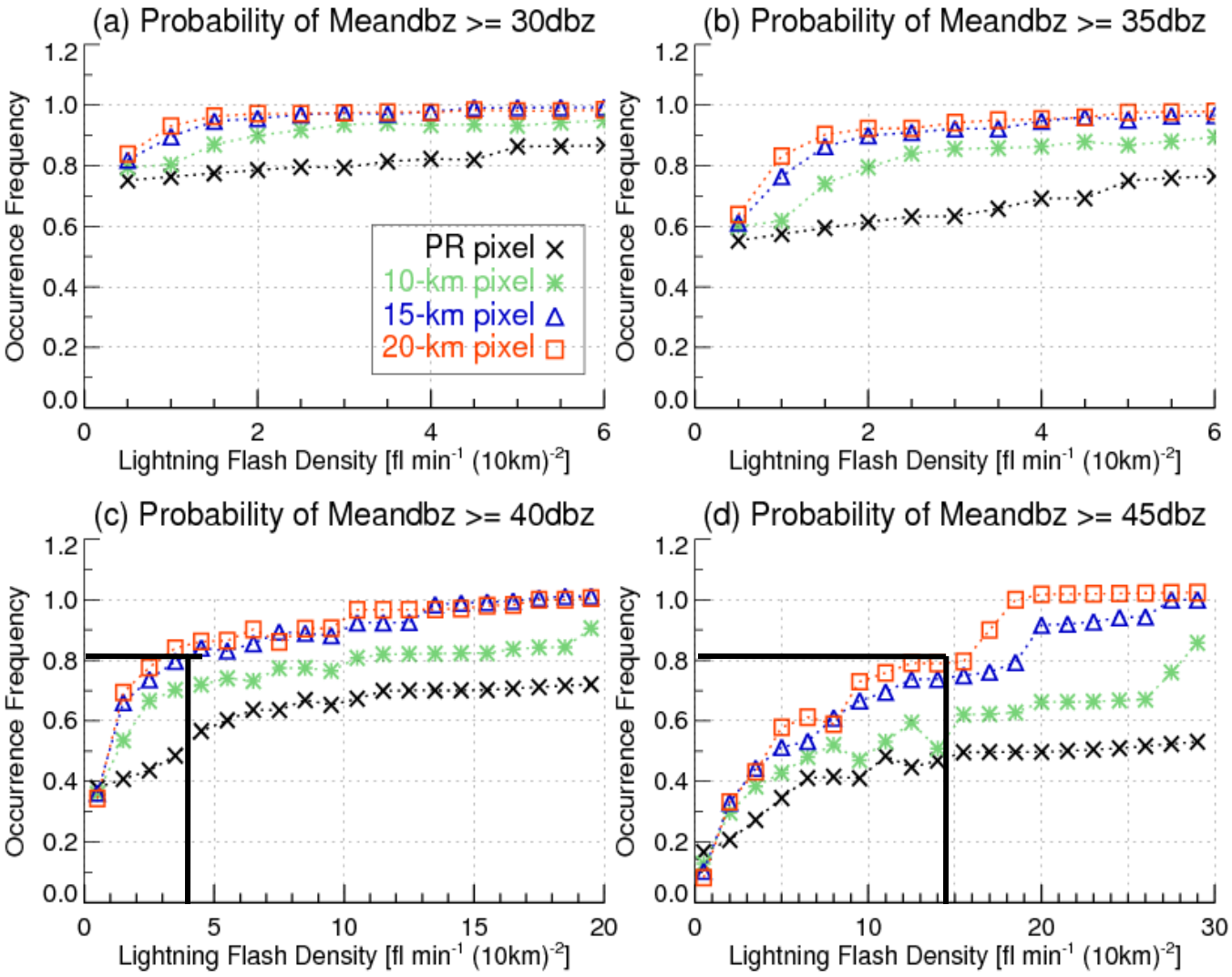




1. Lightning improves the convective detection (POD)
2. Lightning lowers the false alarm (FAR)

“Full” Version of CSTL with Rainfall Rate

Flash Rate Density/ Rain Rate Relationships



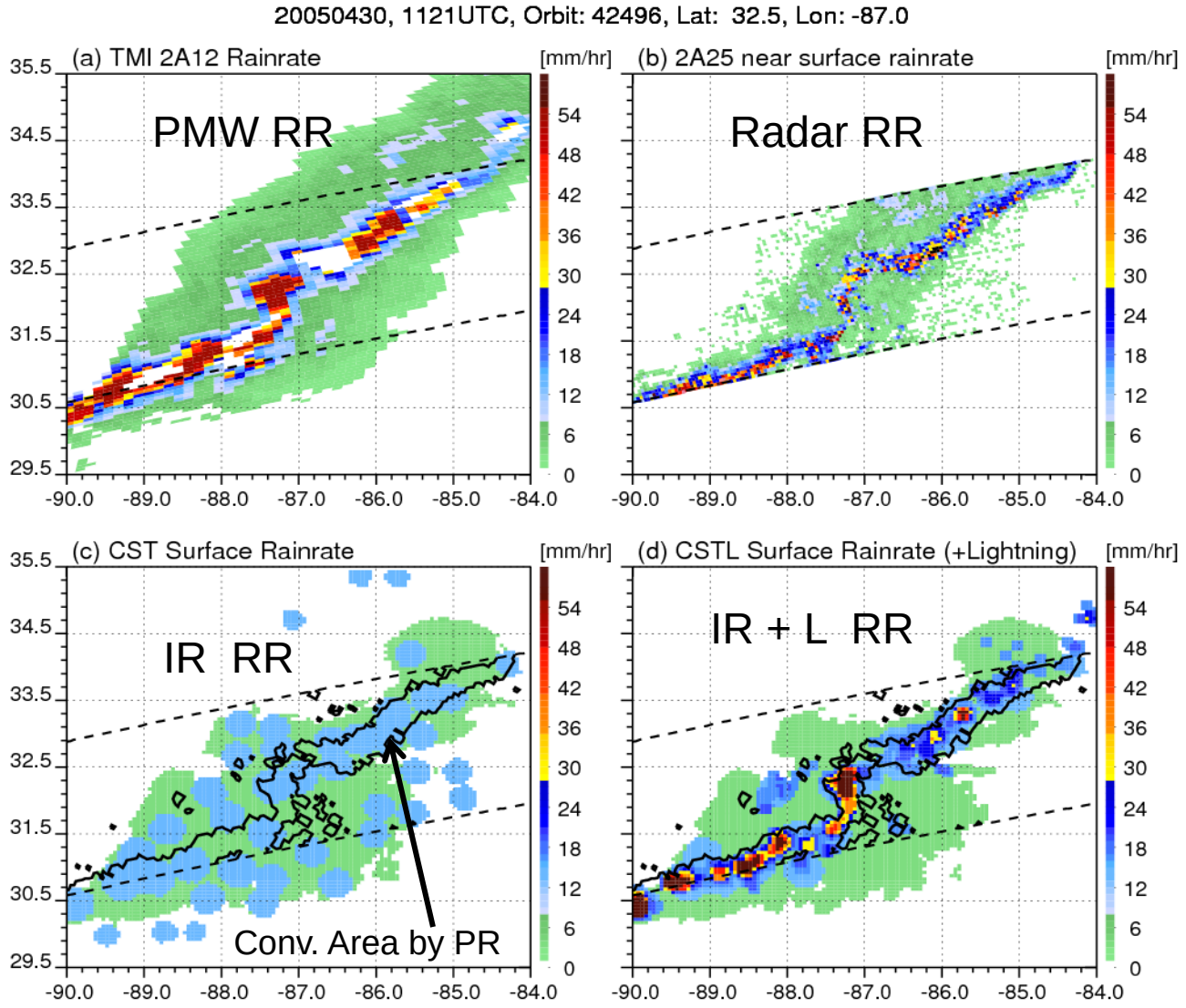
Used to guide assignment of rain rate based on flash density (fl/min/100km^2)

At 20 km resolution:

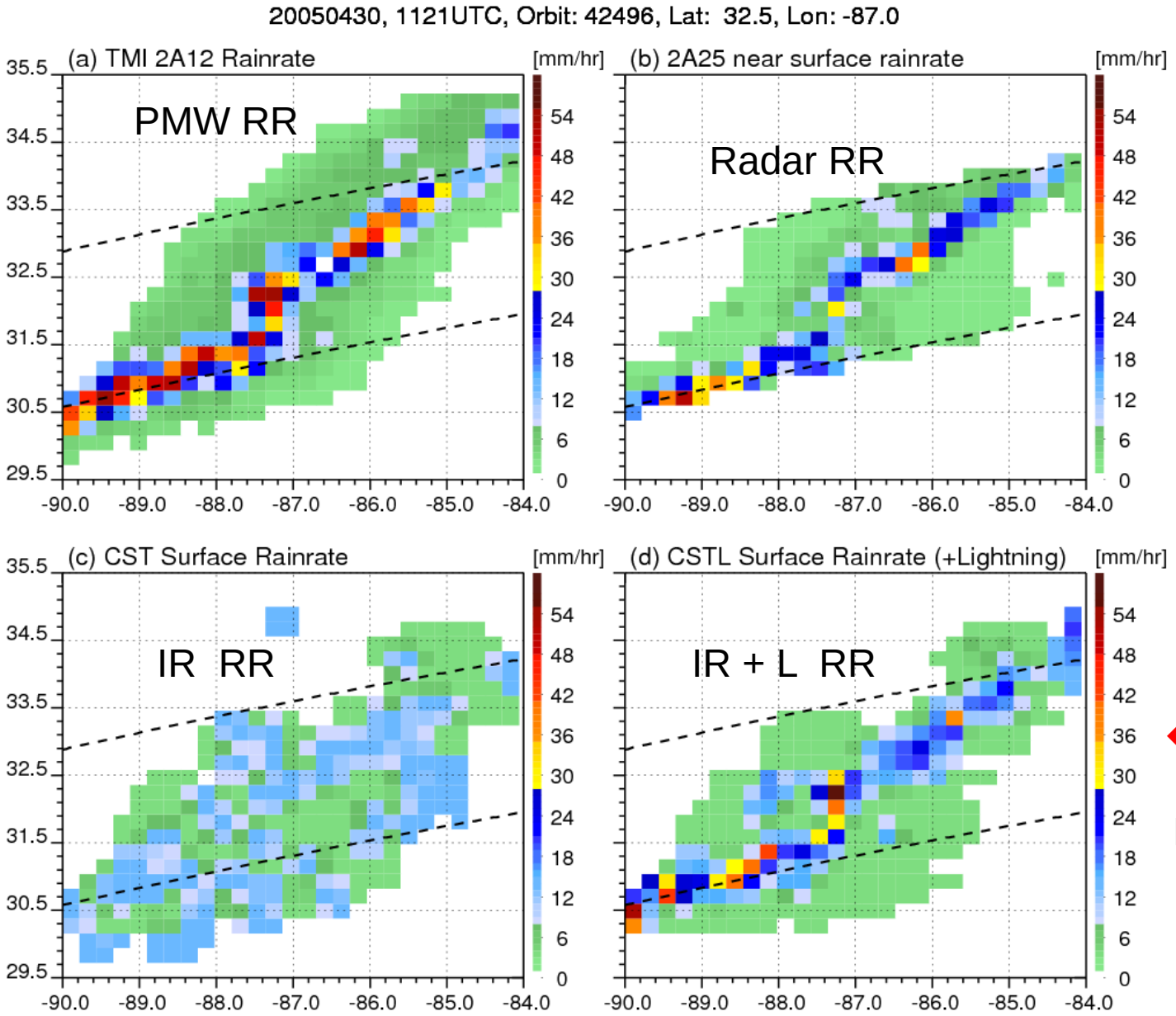
FD	dBZ	RR(mm/h)
4	40	15
15	45	22
35	55	45

Assigning Rainfall Rate

1. Stratiform: 2.5 mm/hr; 2: Convective:12.5 mm/hr;
2. CSTL is assigned discretely with flashes in 20 km;



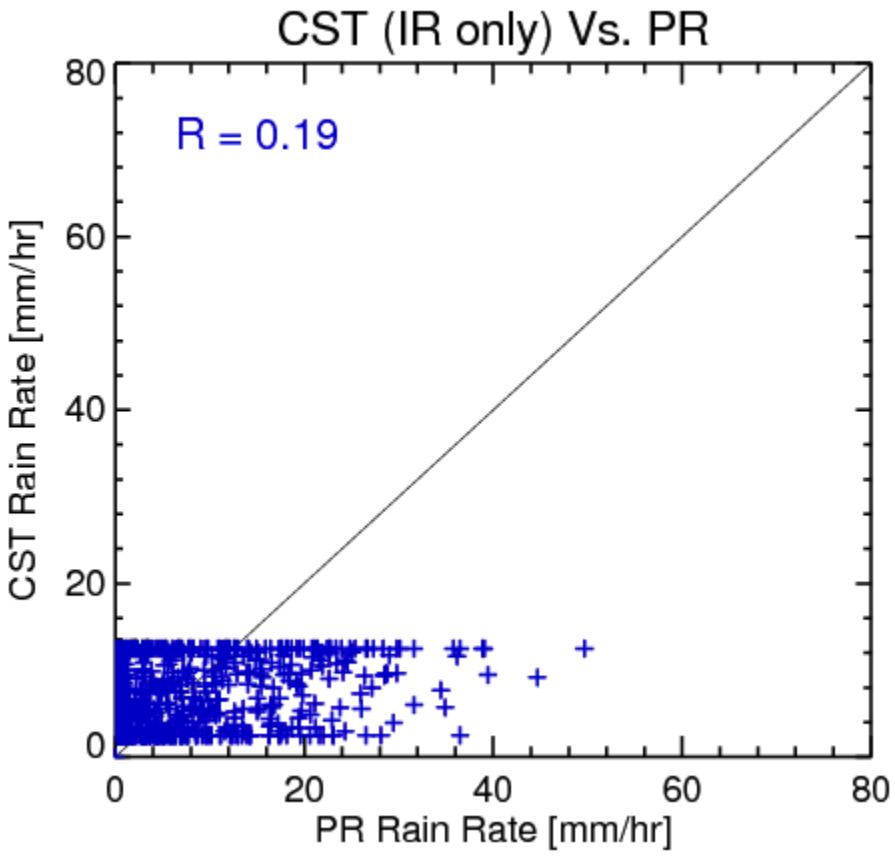
Assigning Rainfall Rate (20 km resolution)

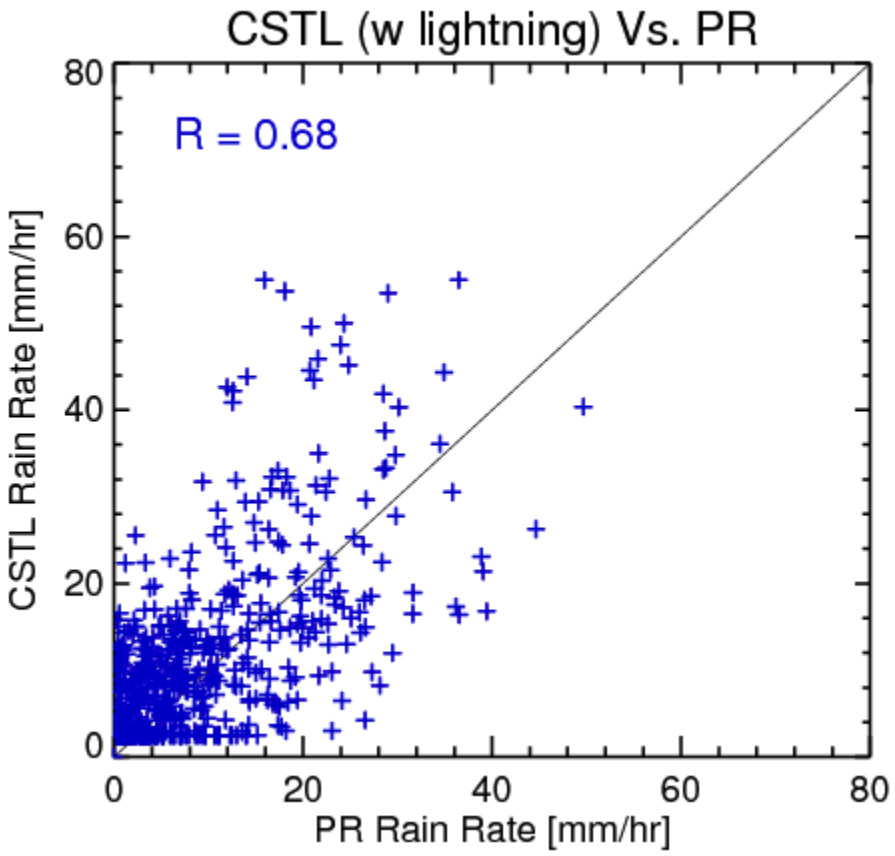


Potential of
← GOES-R
GLM/ABI
Rain Product

Evaluation by PR 2A25 (5 cases)

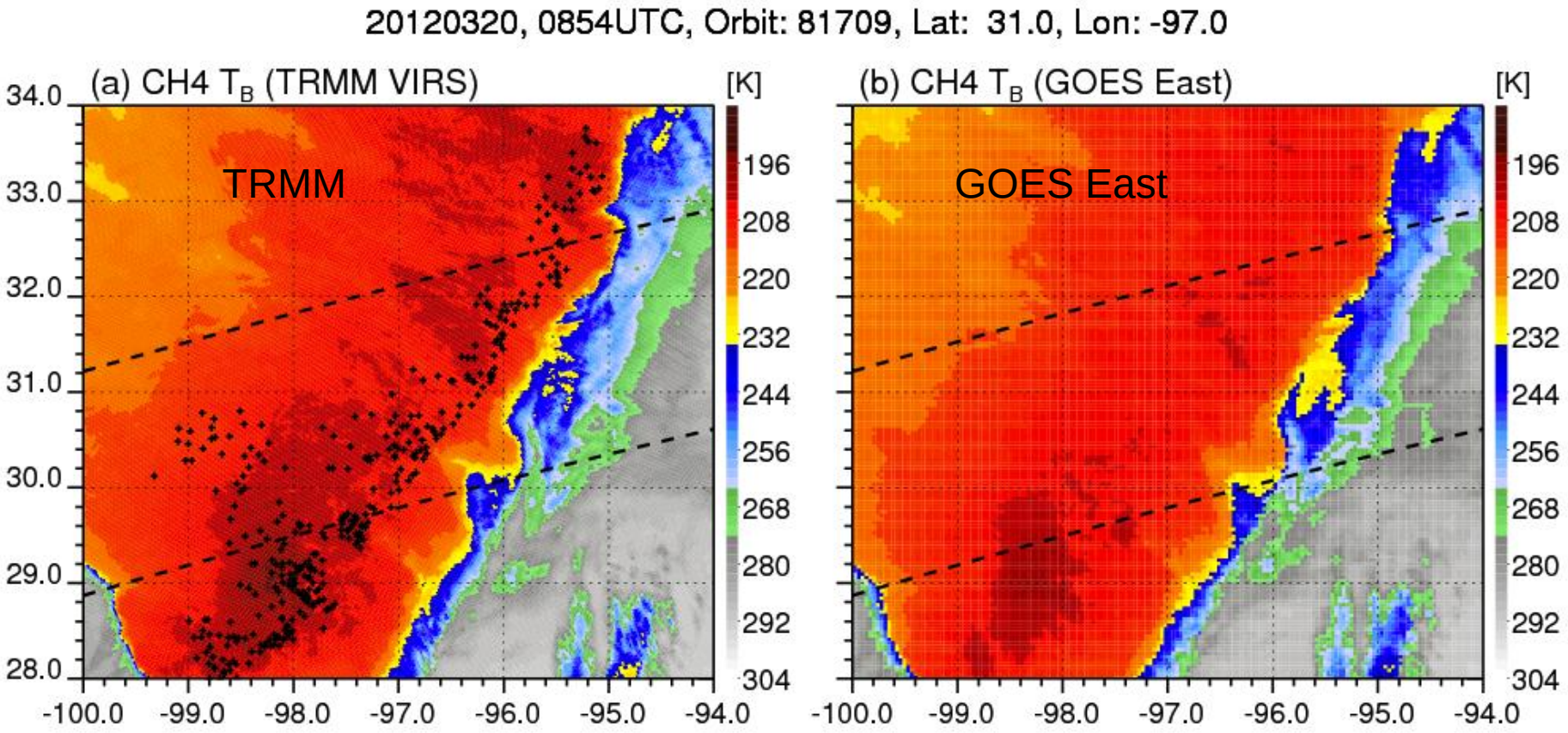
5 cases of mature MCSs are selected for statistics



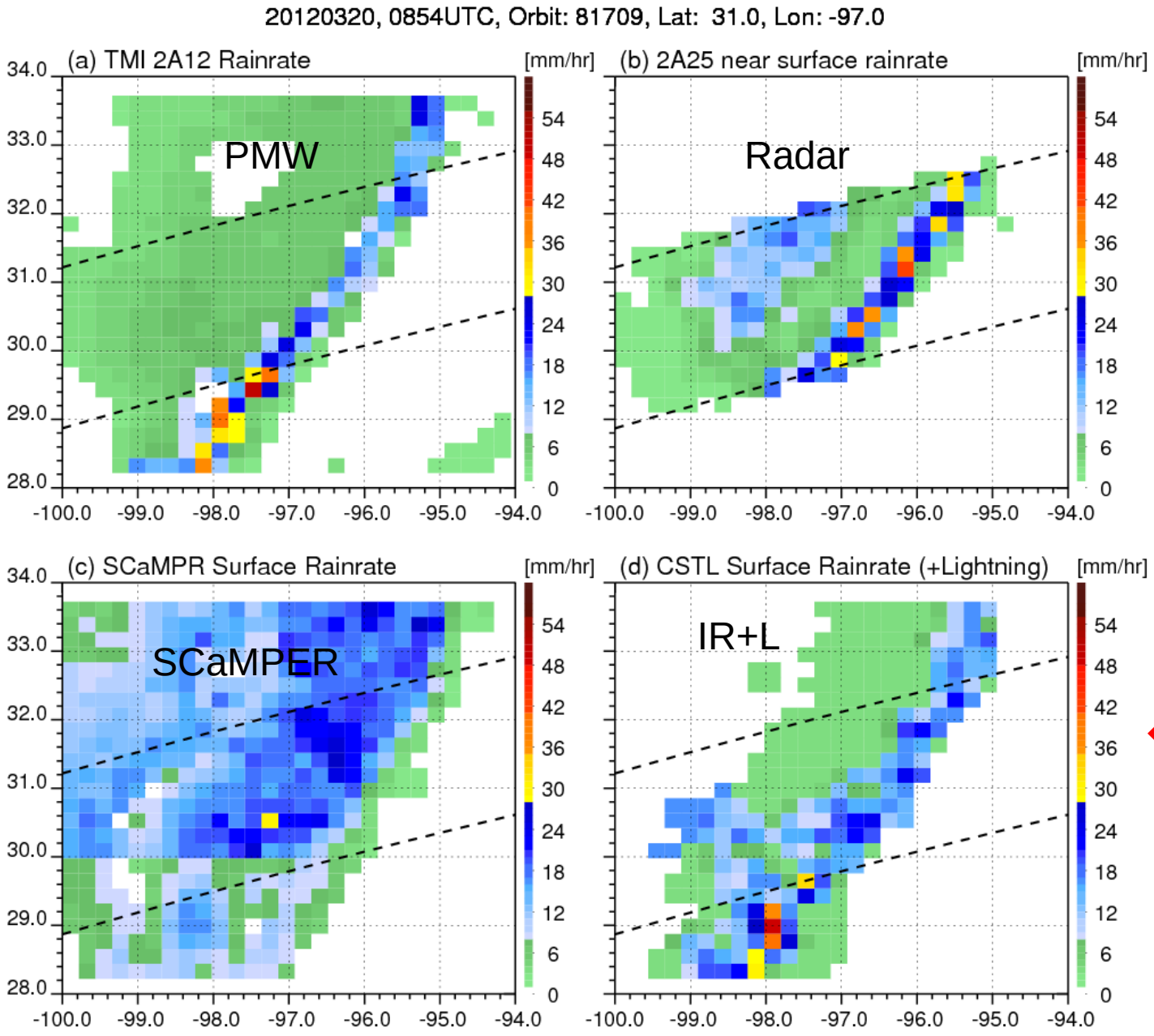


Comparison with SCaMPR/Baseline

1. VIRS and GOES Channels are slightly different
2. Time difference is a few minutes apart



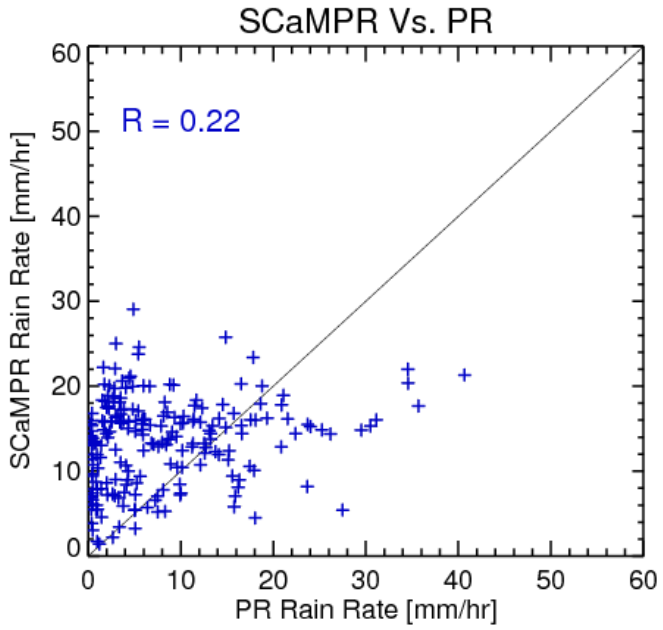
Comparison with SCaMPR

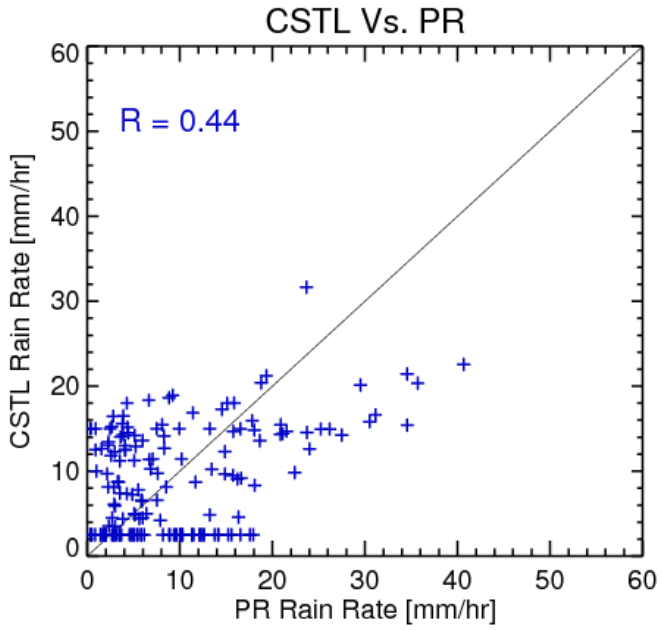


Potential of GOES-R GLM/ABI Rain Product

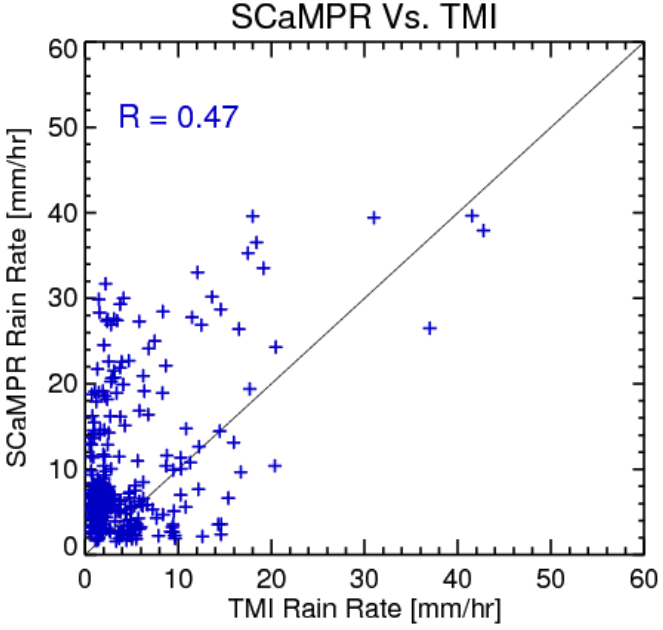
Comparison with SCaMPR

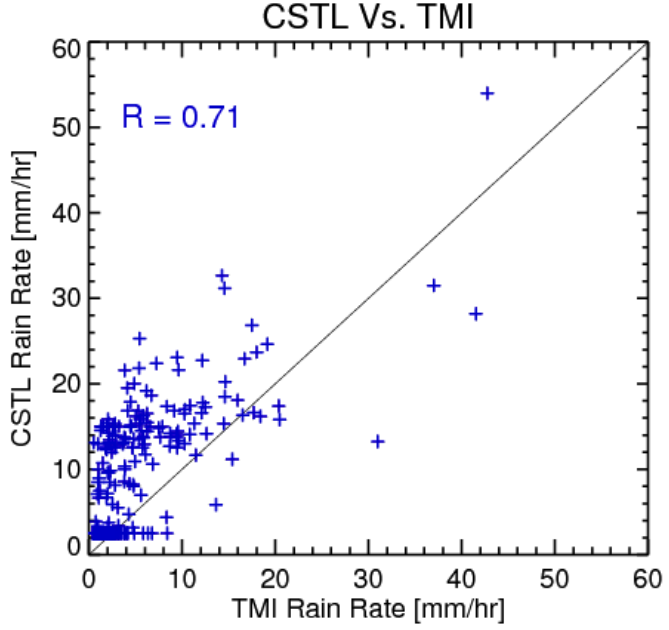
Vs. PR





Vs. TMI





Summary/Next Steps

- Lightning/cloud/rain relations have been established for use in developing GLM/ABI combined rain estimation (papers submitted)
- Initial work completed in developing framework for testing IR (and IR + lightning) rain estimation with TRMM data and for comparing results with GOES-R baseline algorithm
- Preliminary results indicate obvious value of lightning information to establish location of convective cores “unseen” by IR and eliminate incorrect core identification by IR. **Preliminary statistics indicate significant improvement** in rain estimation with use of lightning data
- Next steps include:
  - full analysis of TRMM IR and IR+L rain estimation to carefully quantify lightning impact and its potential and limitations in comparison/ combination with Baseline algorithm
  - use of CHUVA and other data sets to evaluate IR+L with Baseline and test with time resolution/evolution
  - continue analysis of lightning impact on microwave rain retrievals using TRMM data