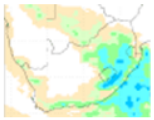
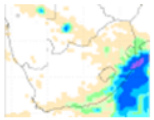
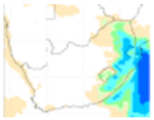
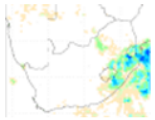
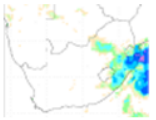
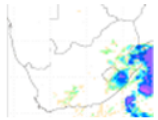
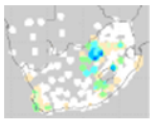
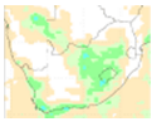
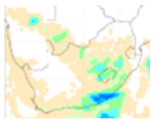
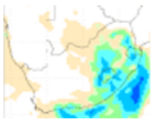
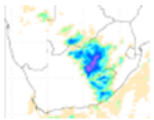
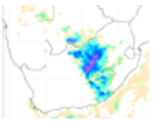
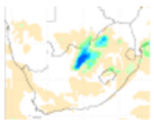
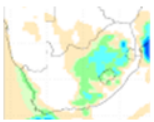
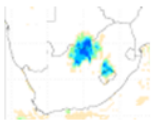
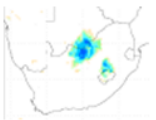
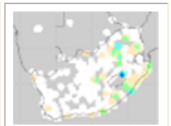
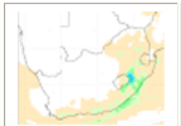
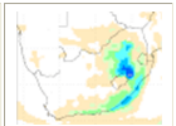
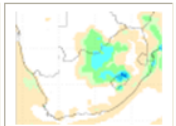
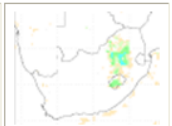
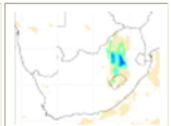
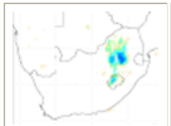
IPWG South African Validation

06-06Z quick-look images

Click here for the Statistics page

Numbers below images are the bias-ratio and correlation

yymmdd	Gauge	NWP_BoM	NWP_ECMWF	NWP_JMA	NWP_MetFr	3B42RT	CMORPH	CPCMMW	GsMAP	Hydro-Estimator
130317	 - | -	 1.386 | 0.249	-	 2.243 | 0.150	 1.277 | 0.238	 0.570 | 0.293	-	-	 1.334 | 0.243	 1.509 | 0.323
130316	 - | -	 1.129 | 0.325	 0.387 | 0.320	 1.298 | -0.018	 2.354 | 0.031	 0.736 | 0.612	 2.686 | 0.667	 2.887 | 0.650	 2.744 | 0.582	 1.148 | 0.115
130315	 - | -	 -99.000 | -99.000	 1.082 | 0.381	 2.546 | 0.198	 4.680 | 0.068	 0.598 | 0.547	 2.387 | 0.685	 2.757 | 0.600	 2.286 | 0.558	 0.476 | 0.046
130314	 - | -	 -99.000 | -99.000	 0.932 | 0.443	 4.062 | 0.274	 2.413 | 0.447	 0.506 | 0.105	 1.175 | 0.123	 1.230 | 0.116	 1.395 | 0.096	 1.248 | 0.127

Error and uncertainty analysis of precipitation estimates

Chris Kidd[1/2], Xin Lin[1/2], Arthur Hou[2]

[1]Earth System Science Interdisciplinary Center, University of Maryland, College Park
[2]NASA/Goddard Space Flight Center, Greenbelt

Background

- Errors and uncertainties within any retrieval scheme comprise of a number of issues – such as Tb accuracy, internal retrieval uncertainties, original calibration, etc.
- Elucidating errors and uncertainties is compounded by the errors and uncertainties within any calibration, verification and validation data
- Combining different data sets necessitates knowledge of individual errors and uncertainties within each data set

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- Underlying premise that errors and uncertainties can be identified through the inter-comparison of precipitation estimates; this is particularly true for truly independent observations.
- Many errors/uncertainties in data products can be identified through spatial analysis – they are often location-persistent.

Many errors and uncertainties are not random – they need to be constrained!

Fundamentals

error ***(noun)***

a mistake

- He admitted that he'd **made an error**
- The letter contains a number of **typing errors**.
- **Human error** has been blamed for the air crash.
- With something as delicate as brain surgery, there is little **margin for error** (= you must not make mistakes).

error of judgment

- **a wrong decision** (*Not telling the staff before they read the news in the papers was an error of judgment*)

see the error of *your* ways

- to understand that you were wrong to behave in a particular way and start to behave differently

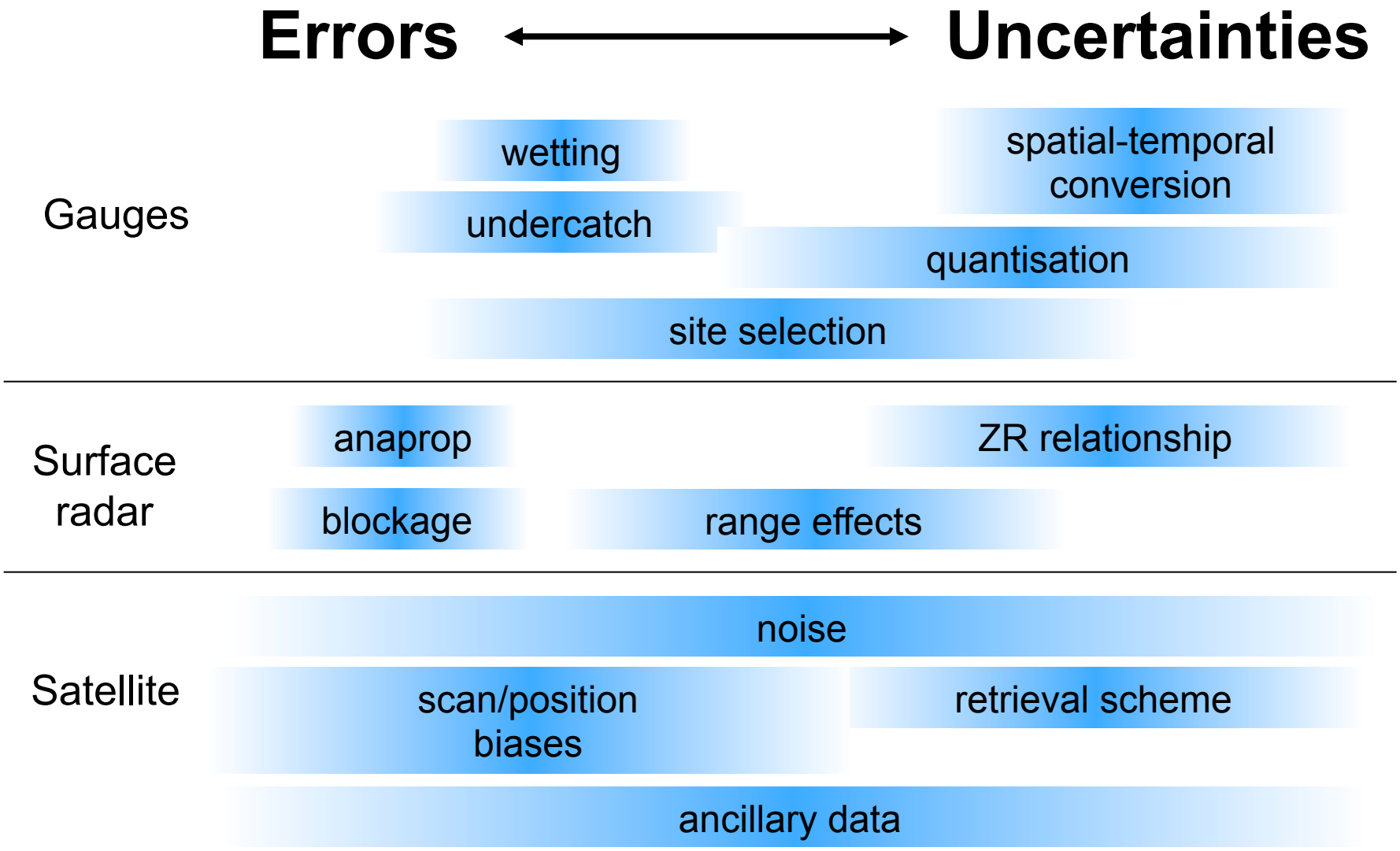
uncertainty ***(noun)***

when something is not known, or something that is not known or certain

- Nothing is ever decided, and all the uncertainty is very bad for staff morale.
- Life is full of uncertainties

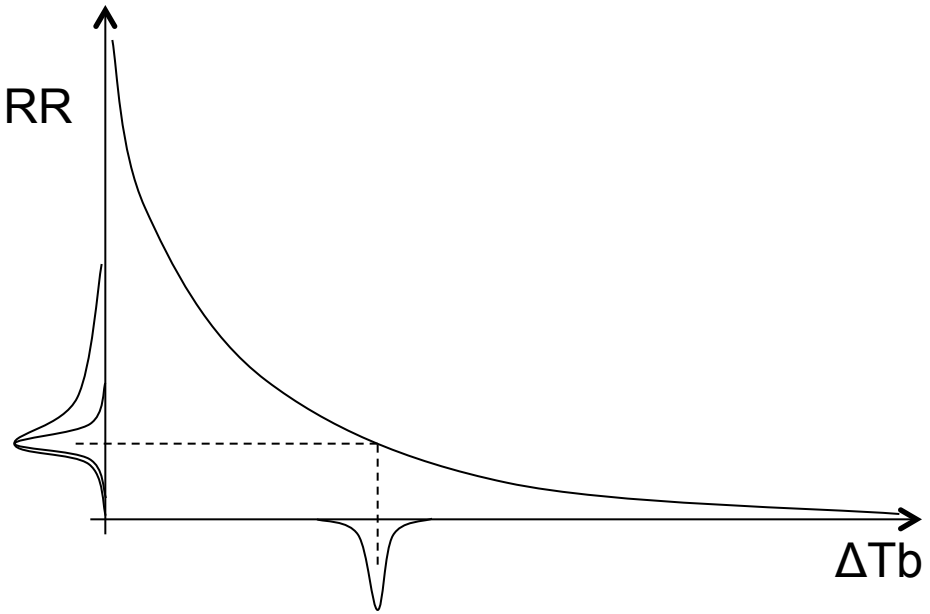
i) **Errors can *(should)* be constrained through quality-control of data, e.g. Fundamental Climate Data Records (FCDR)**

ii) **Uncertainties relate more to retrieval methodologies – such as the incomplete knowledge of physical processes.**


Errors
Uncertainties
Gauges
wetting
undercatch
spatial-temporal conversion
quantisation
site selection
Surface radar
anaprop
blockage
ZR relationship
range effects
Satellite
noise
scan/position biases
retrieval scheme
ancillary data

Simple case…

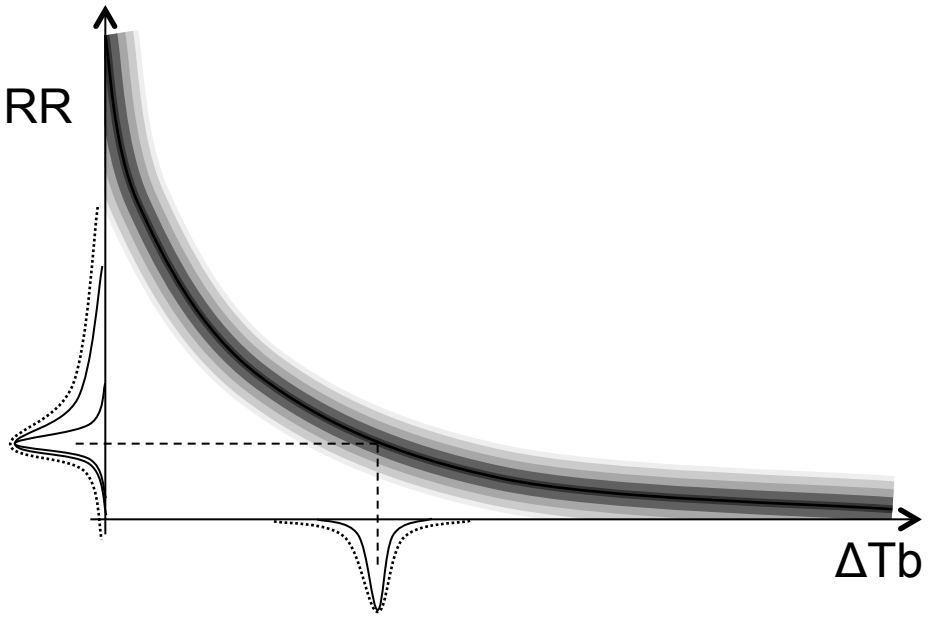
Assuming perfect calibration data



- but no such thing as ‘perfect’ calibration – the relationship itself will be imperfect
- translation of errors from ΔTb to RRs should be asymmetric

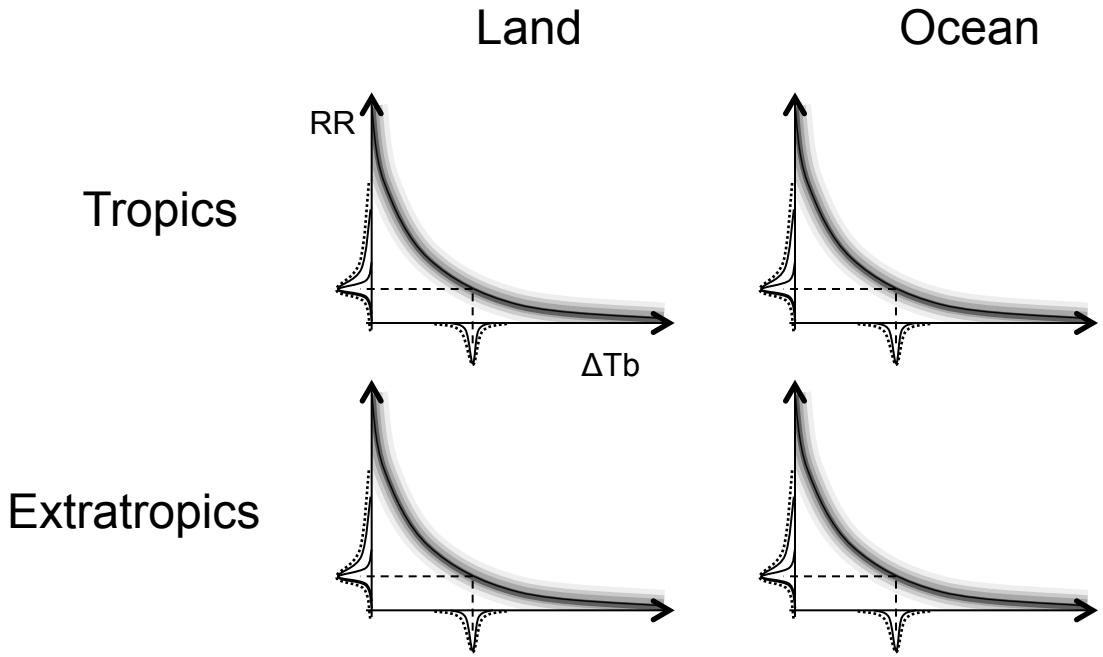
Simple case…

Assuming ‘real’ calibration data



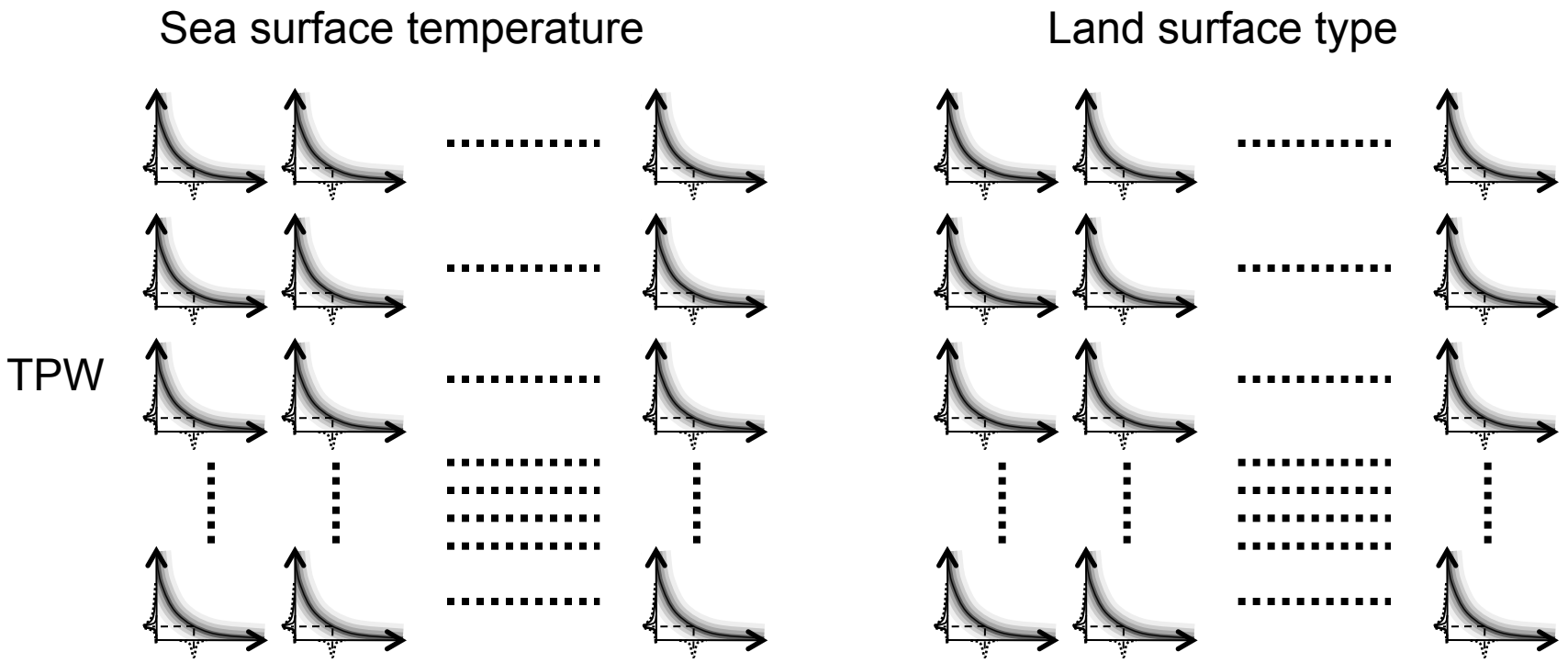
- requires some knowledge of the calibration data sets – and their implementation/impact in/on the retrieval algorithm(s).

… a more realistic case…



The number of uncertainty ‘tables’ need to reflect the internal retrieval scheme groupings

Multi-dimensional constraints

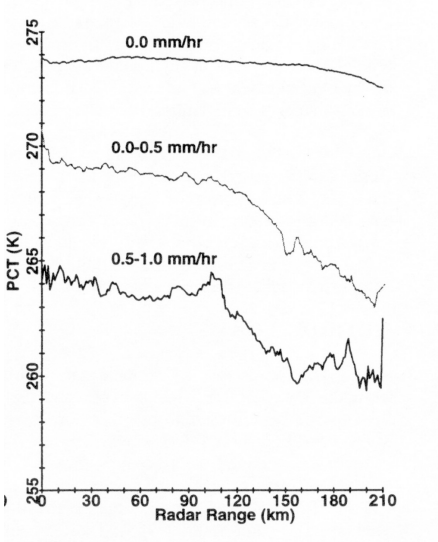


Database source for each retrieval needs to be recorded – each will have different uncertainty characteristics

BUT – how do we ensure any consistency?

Cross-comparison of satellite/surface

- Analysis of AIP-3 (TOGA-COARE) radar data vs satellite estimates showed significant range effects >100 km (Kidd 1997)



- Spatial mapping of radar errors identifying range effects and surface clutter

Surface \ Satellite	R	NR
R	R:R	R:NR
NR	NR:R	NR:NR

Identification of errors by mapping contingency tables

Surface/spaceborne radar comparison

Study area: southern US, 2009-2012

Surface radar data – NMQ

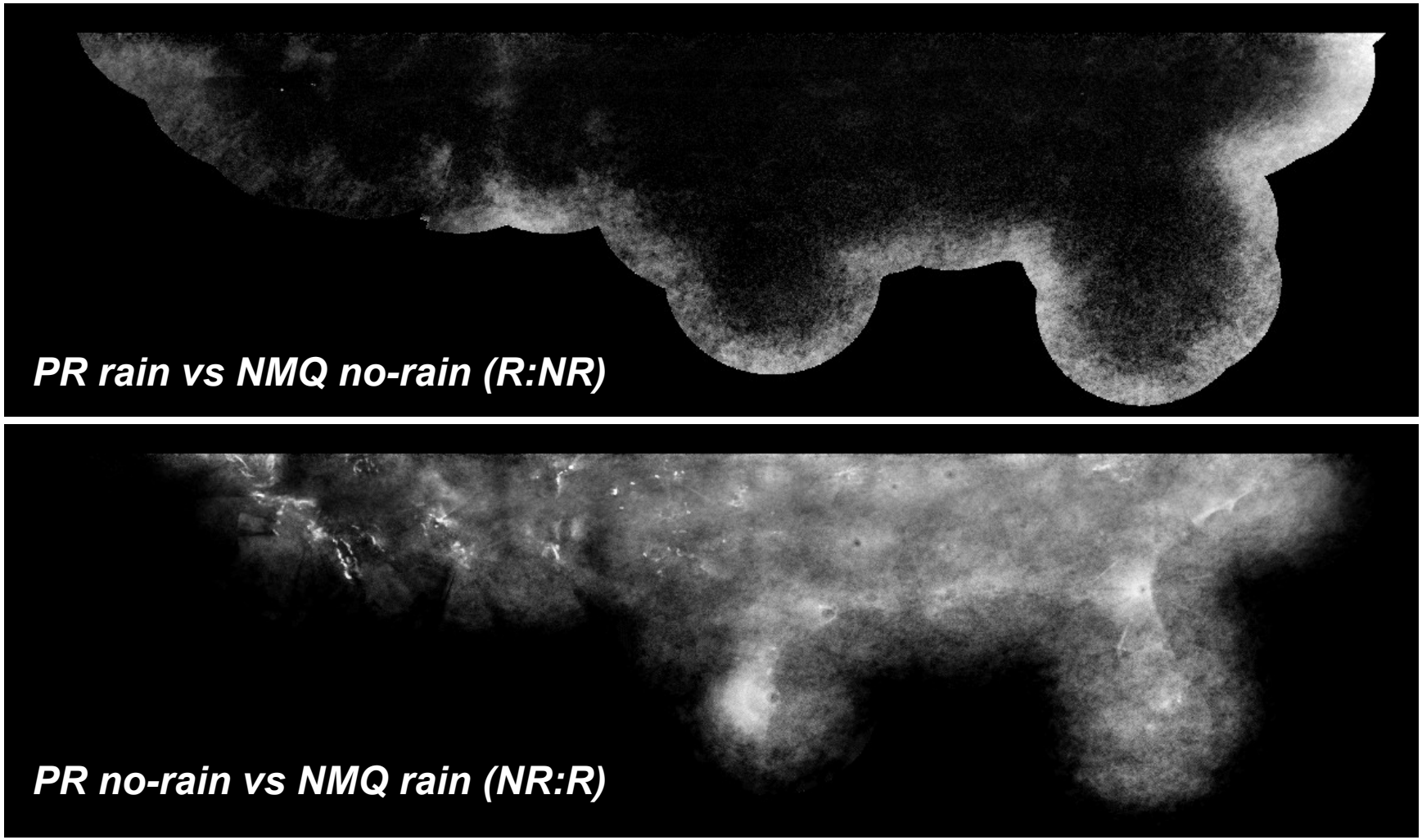
- 0.01 x 0.01 degree, 5 minute, surface rainrate

TRMM Precipitation Radar

- 5 km, instantaneous, near surface, estimated surface and average rainrates

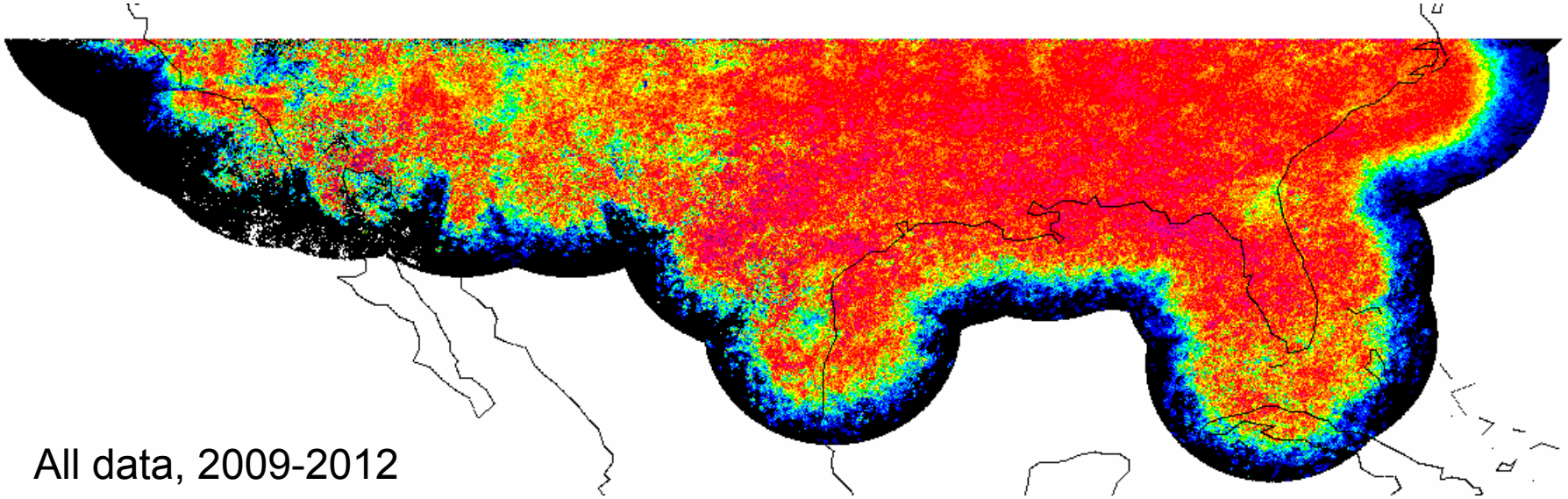
- Coincident/co-temporal surface/satellite measurements
- NMQ radar data for 5x5 boxes averaged to ~equal PR
- NMQ radar used for period of PR observation

TRMM PR vs NMQ surface radar



Generation of Heidke Skill Scores based upon the contingency tables

NMQ-PR HSS scores (RR>0.7 mm h^{-1})

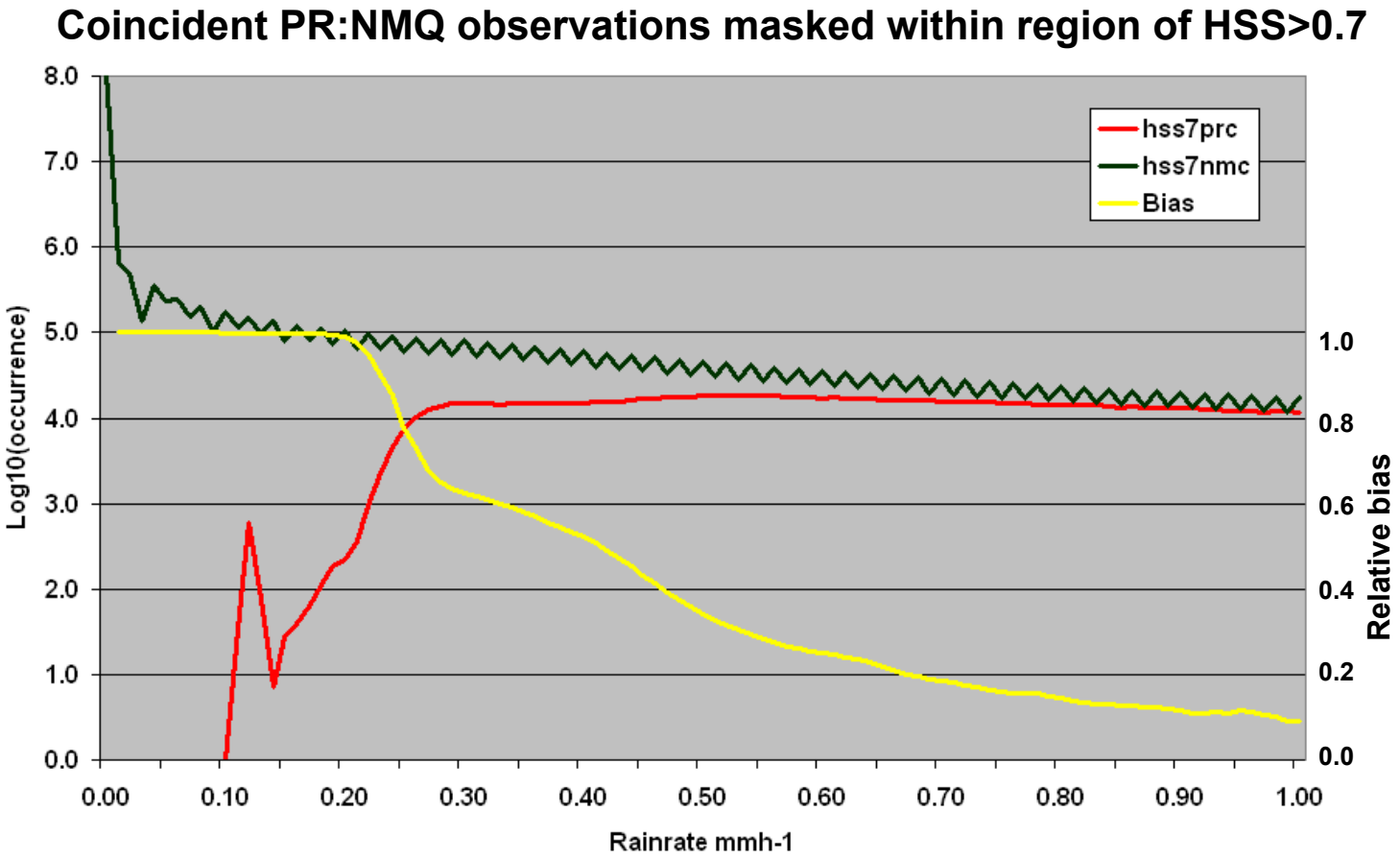


All data, 2009-2012

Sampling and rain characteristics affect the scores

Scores better over the eastern region…

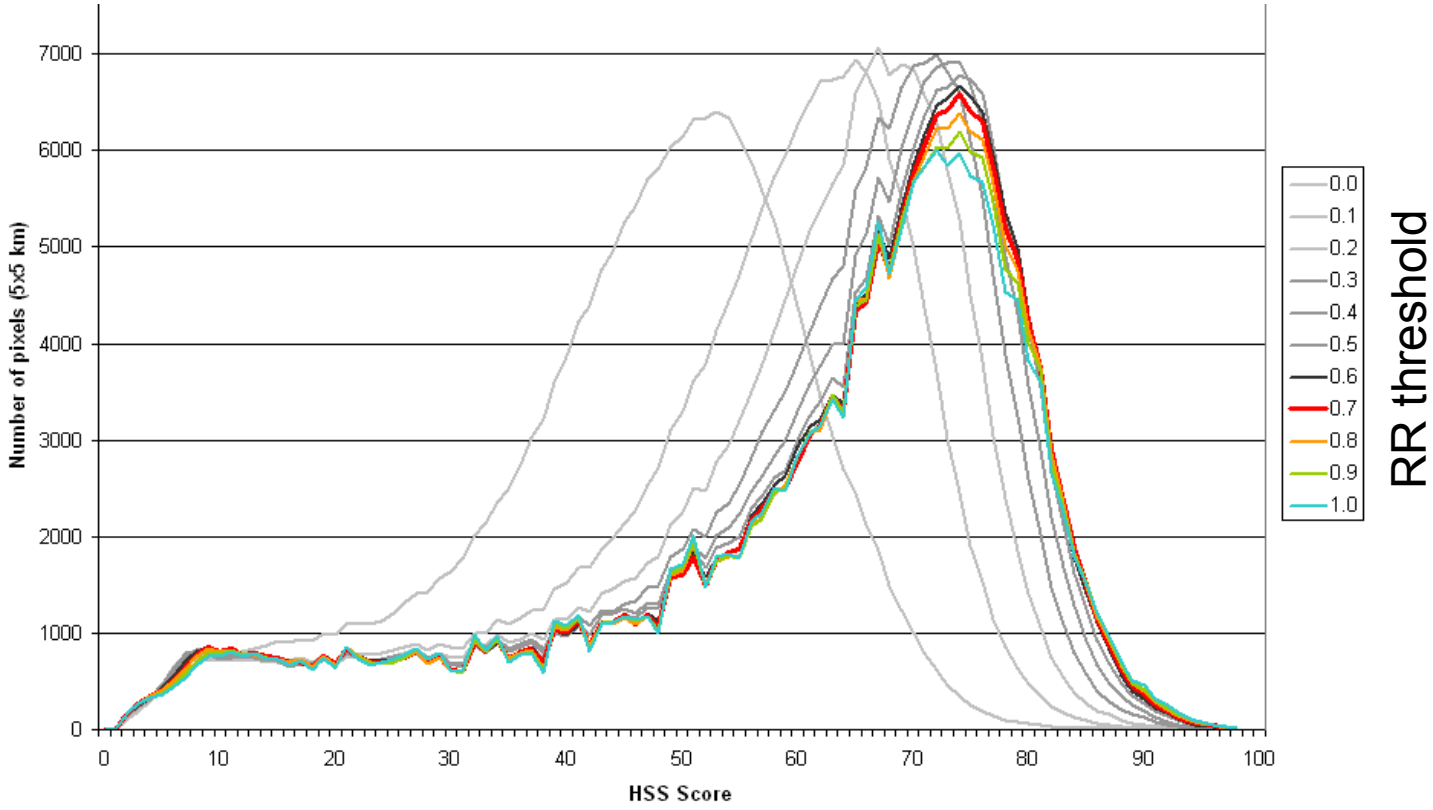
Occurrence of precipitation: NMQ vs PR



The absolute lowest rainrate detection is about 0.1 mm h^{-1}, although the 50% detection level is 0.4 mm h^{-1}. At 0.7 mm h^{-1} the detection is 80%, while at 1 mm h^{-1} the detection rate is about 92% (of that seen by the surface radar).

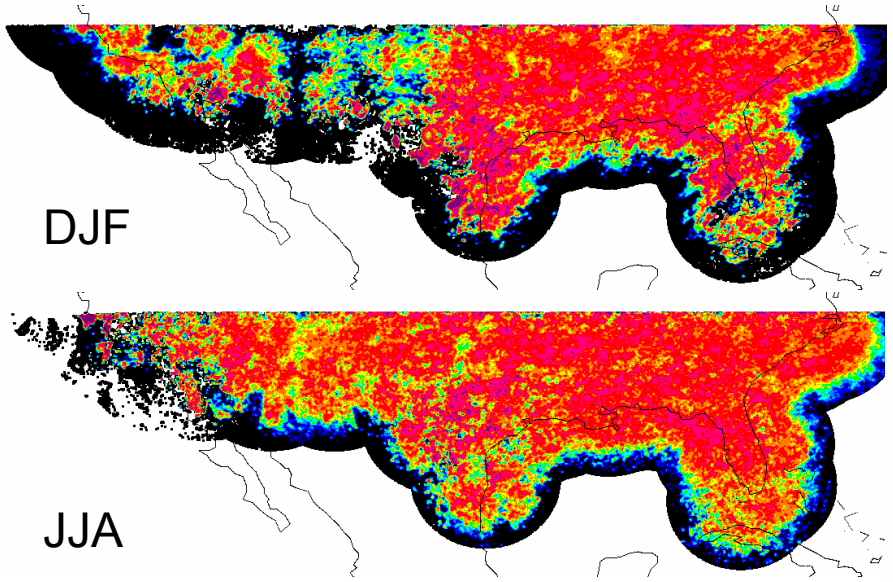
NMQ vs PR HSS scores

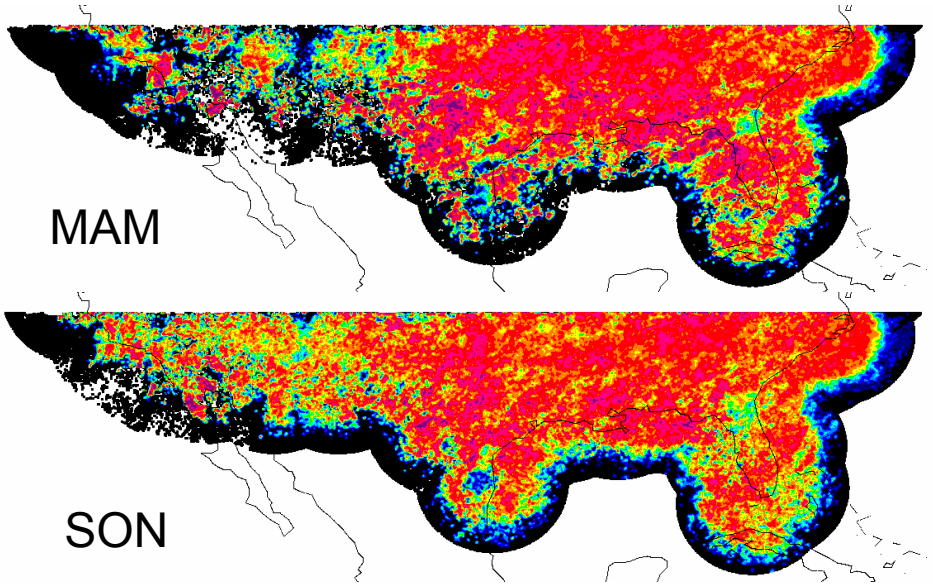
NMQ surface radar vsTRMM PR over southern US, thresholded RR



For identification of artefacts in NMQ surface radar data 0.6/0.7 mm h^{-1} appropriate: below this threshold significant changes with threshold occur, while above, no significant changes occur.

NMQ-PR HSS scores (RR>0.7 mm h^{-1})



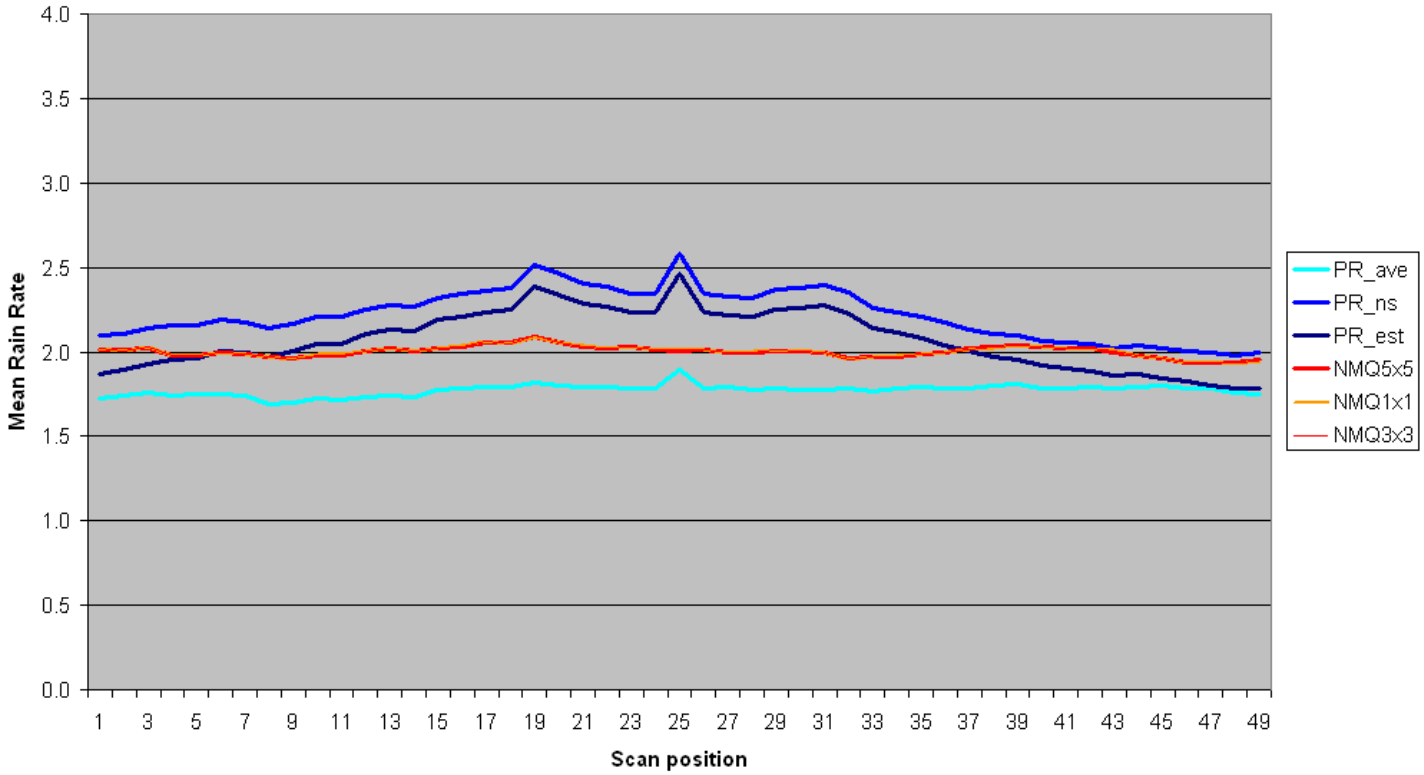


3x3 smoothing applied

! Sampling and rain characteristics will affect the scores

Seasonal variations, particularly in the west

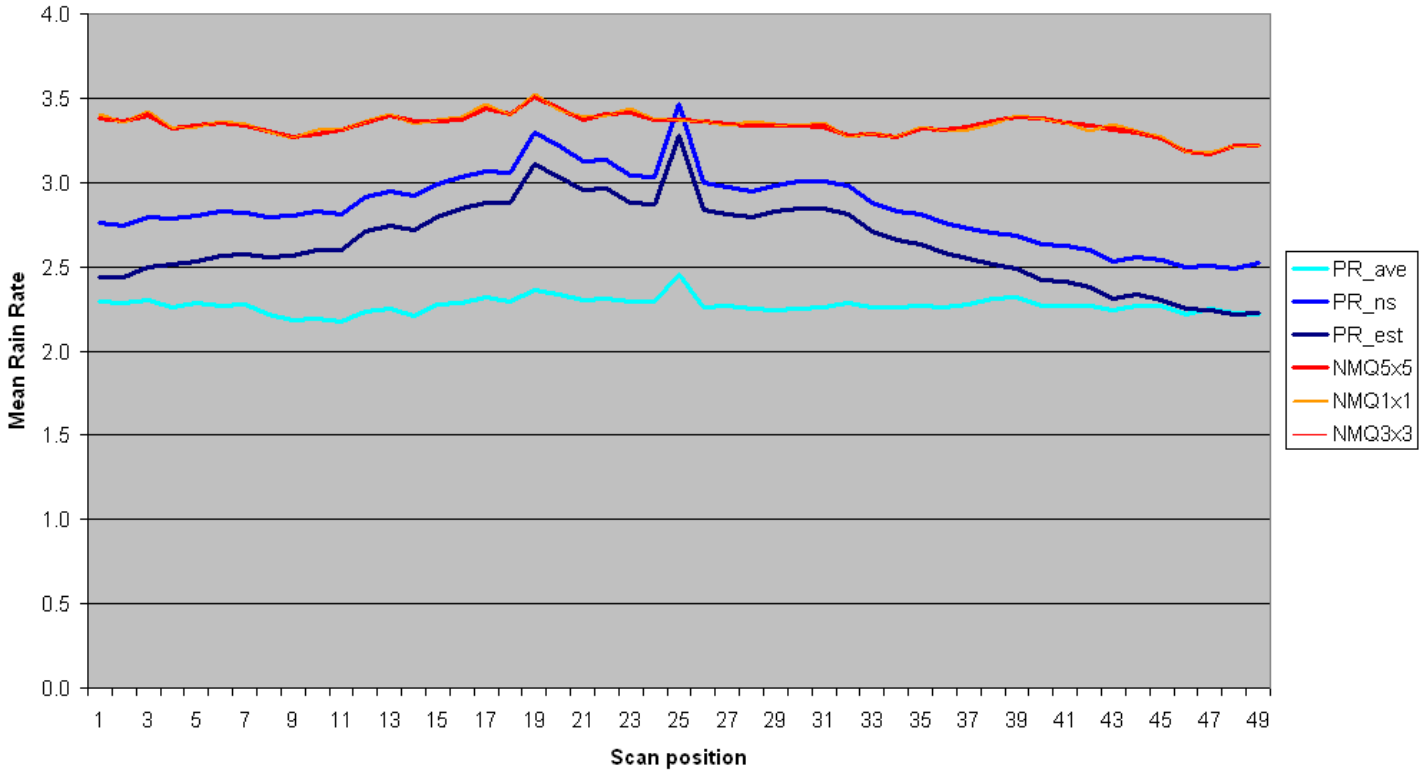
PR vs NMQ: mean rainrate, all data



All NMQ/PR coincident data, PR (2-4km ave, near surface and surface estimate)

- Cross-track PR scan issue
- All NMQ resolutions (1x1, 3x3 and 5x5) almost identical.
- “All data” suggests PR is generally higher than NMQ

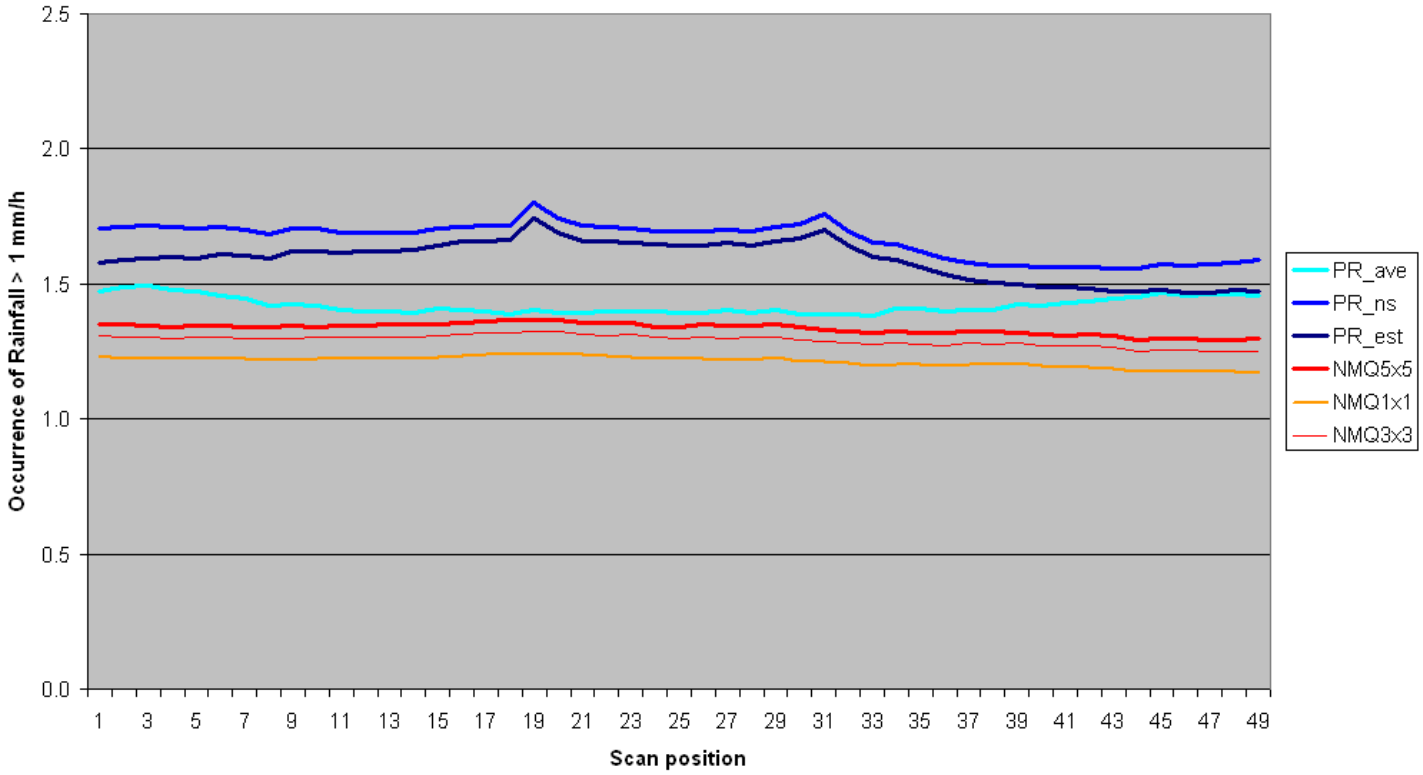
PR vs NMQ: mean rainrate, HSS>0.7



Coincident data for NMQ/PR HSS>0.7, PR (2-4km ave, near surf. and surf. est.)

- Cross-track PR scan issue
- All NMQ resolutions (1x1, 3x3 and 5x5) almost identical.
- Higher mean rainrates due to more intense overland rainfall
- NMQ higher than PR – although at nadir, similar.

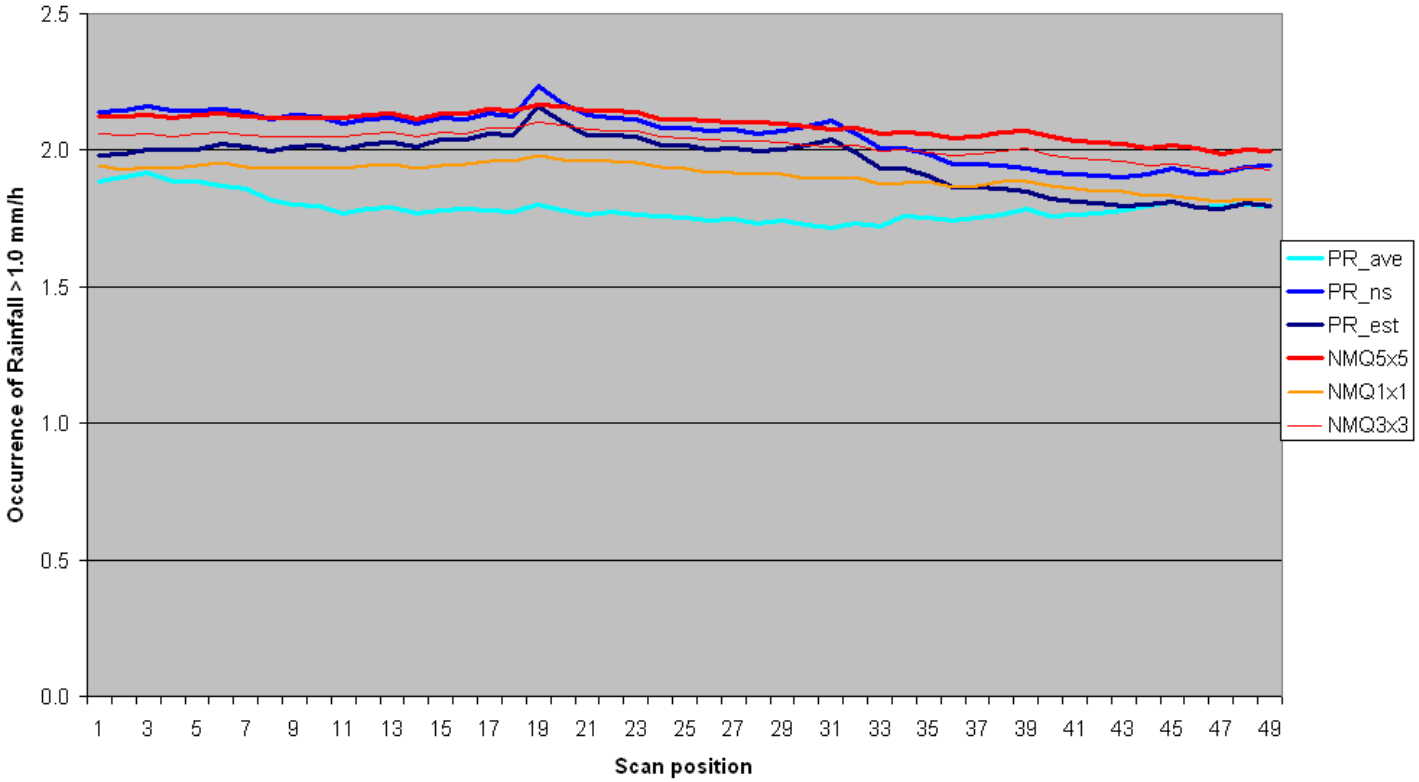
PR vs NMQ: rain occurrence, all data



All NMQ/PR coincident data, PR (2-4km ave, near surface and surface estimate)

- Cross-track PR appear to have a double peak.
- All NMQ resolutions (1x1, 3x3 and 5x5) vary due to beam filling
- "All data" suggests PR is generally higher than NMQ

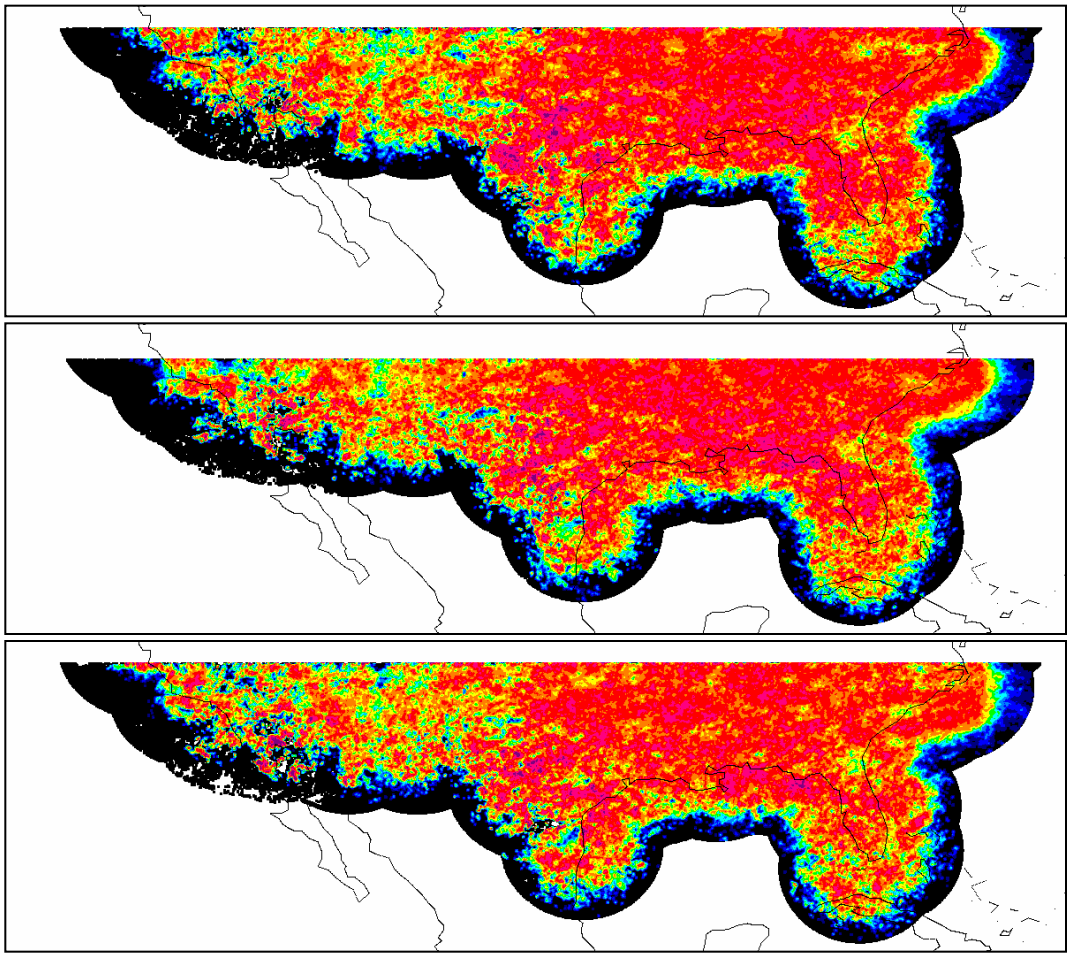
PR vs NMQ: rain occurrence, HSS>0.7



Coincident data for NMQ/PR HSS>0.7, PR (2-4km ave, near surf. and surf. est.)

- Surface NMQ/PR retrievals very similar – 'near surface' closer than 'estimate'
- All NMQ resolutions (1x1, 3x3 and 5x5) vary due to beam filling.
- Higher rain occurrence due to more overland rainfall

NMQ-PR HSS scores (RR>0.7 mm h^{-1})



TRMM PR scanpos 01-16

TRMM PR scanpos 17-33

TRMM PR scanpos 33-49

Overall patterns similar (e.g. inland of Jacksonville and Brownsville)

TRMM PR scan positions 33-49 appear to be poorer than 01-16

Extension to extra-TRMM regions

How do you verify surface reference data sets outside the TRMM PR region?

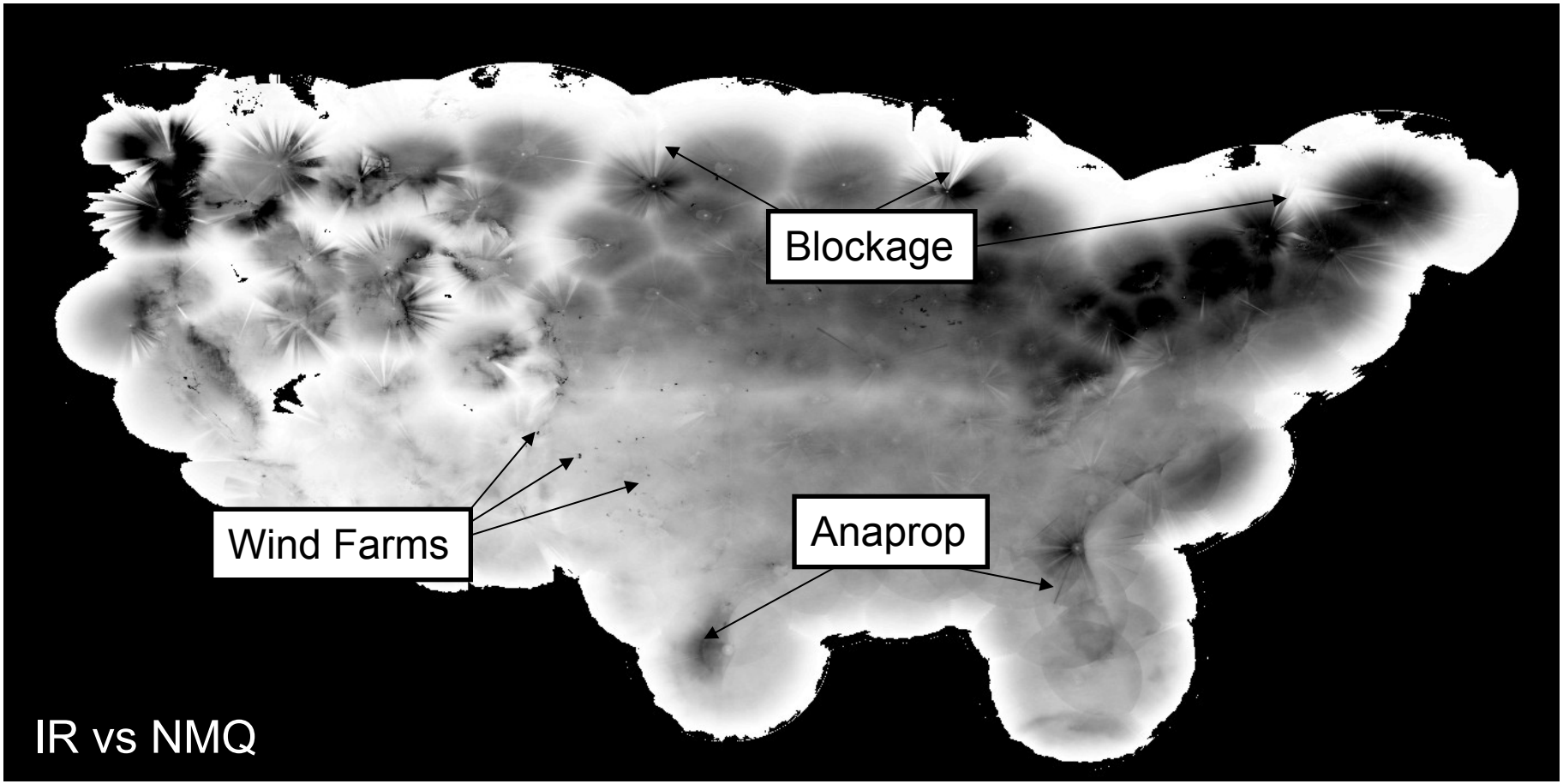
Proxy spatial rainfall information:

- *Global IR data (simple Tb thresholding)*
- *Numerical models*

Surface radar data are inconsistently correct

Infrared retrievals/models are consistently incorrect

Extension to extra-TRMM regions



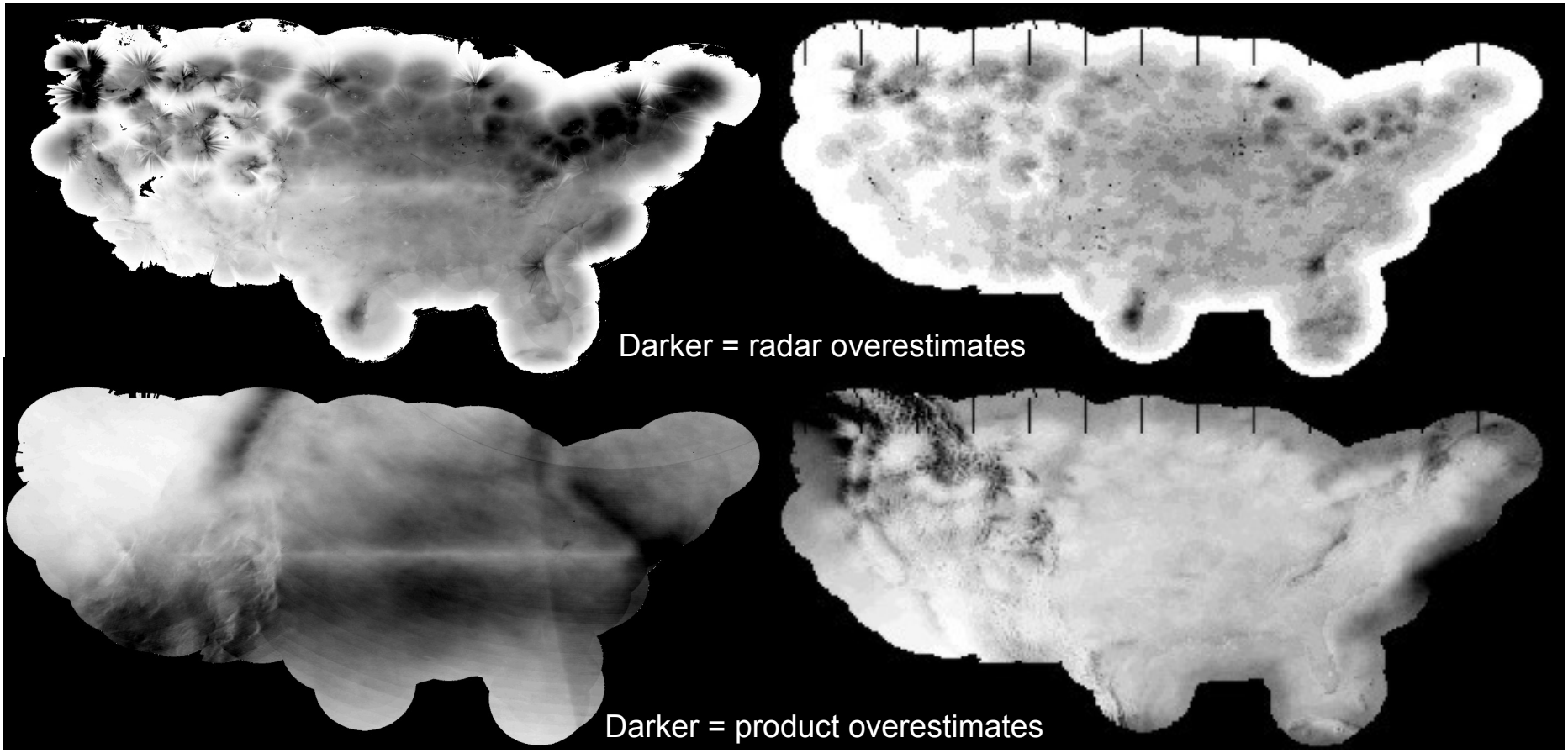
Use of Global IR data as proxy for rain: radar over/under-estimation

Discrepancies should be large-scale – small scale features radar-related

IR & ECMWF vs NMQ

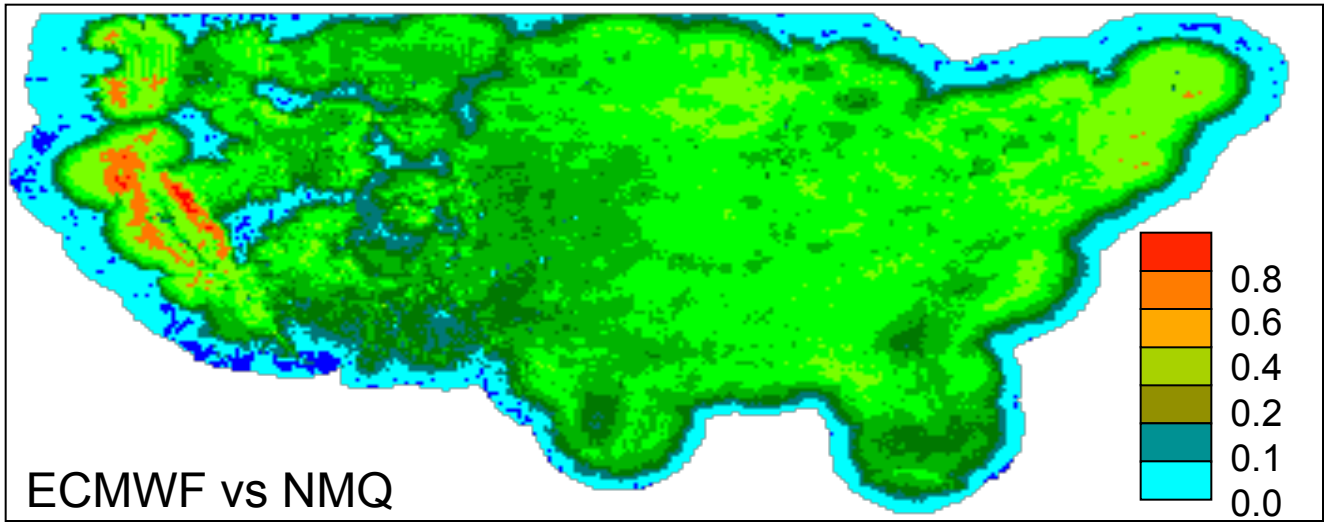
IR comparison

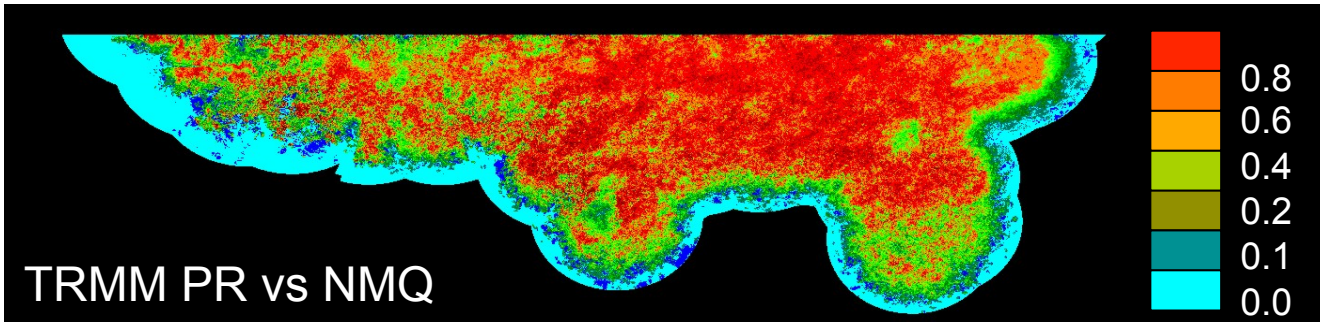
ECMWF comparison



Radar 'overestimates' similar in both IR and ECMWF comparisons

HSS scores: ECMWF & PR vs NMQ

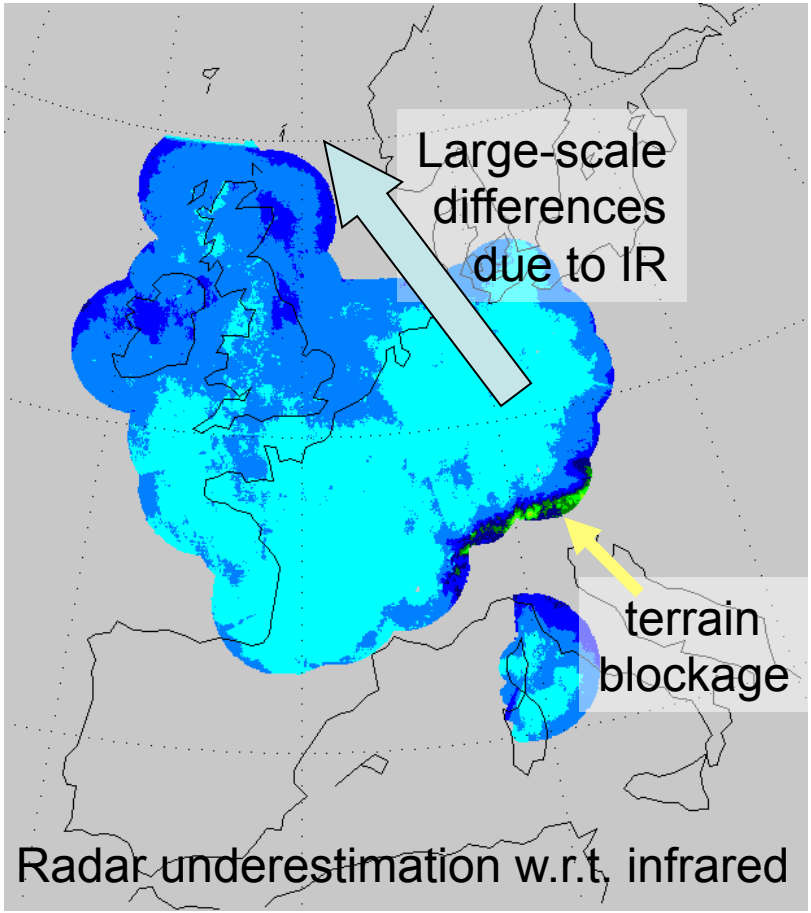


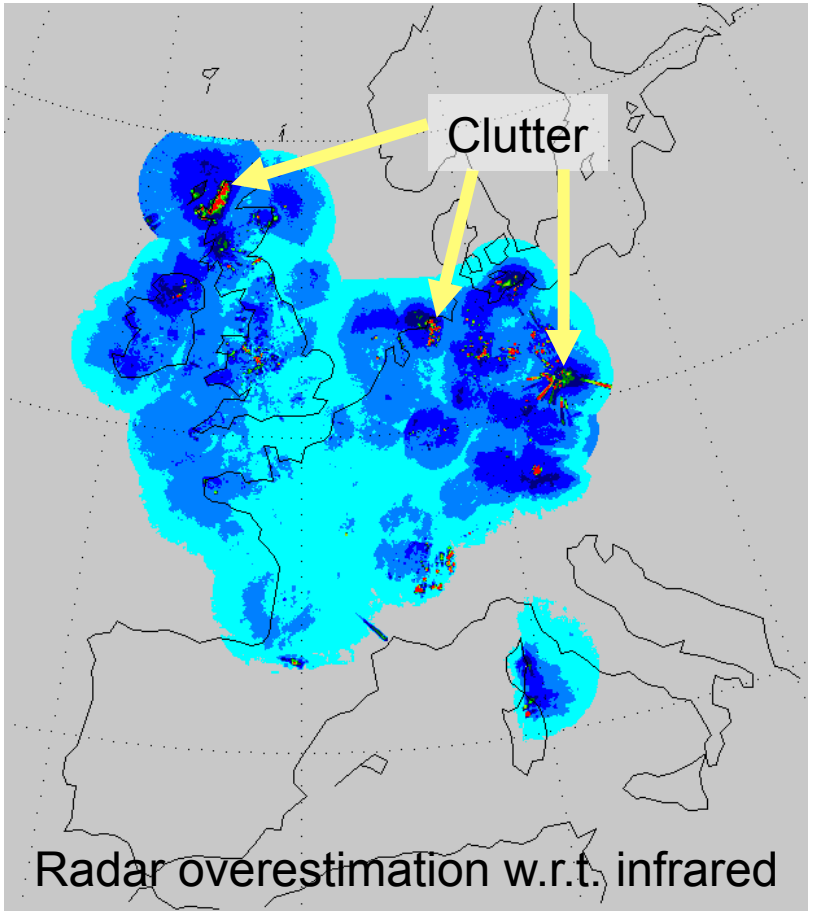


General form of patterns in east similar

Similar observing systems agree well: e.g. radar/radar

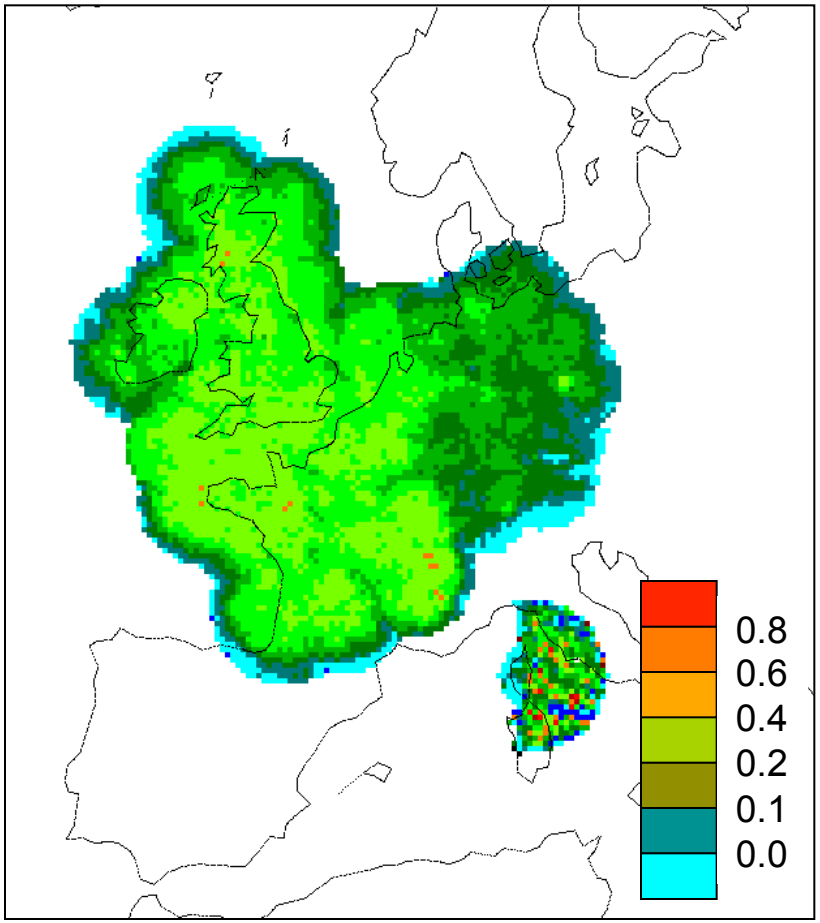
European (Nimrod) radar error mapping





Extension of technique to European *OPERA* & Australian *Rainfields*

Europe: UKMO-Nimrod radar vs ECMWF



Heidke Skill Score (0.5 mmh-1 threshold)

- Radar range is a significant artefact
- Eastern region – different surface radar thresholding?

Extension of technique to European *OPERA* & Australian *Rainfields*

Conclusion

- Knowledge of errors and uncertainties vital for combined products – particularly for ‘level 4’ products

- Inter-comparison of products can help to elucidate and quantify errors within component precipitation products

- Uncertainties, by their very nature, are more multi-dimensional; knowledge of a techniques processing path critical in uncertainty analysis.

and finally…

22-23 November 2012 – UK

Fine frontal structure, intensities > 50 mm h^{-1}

28 June 2012 – UK midlands

Storms not unusual; 2012 2nd wettest on record - 1330 mm ~ same as Alabama mean!
Tornados, polar lows, SF12-winds not uncommon – winter *and* summer

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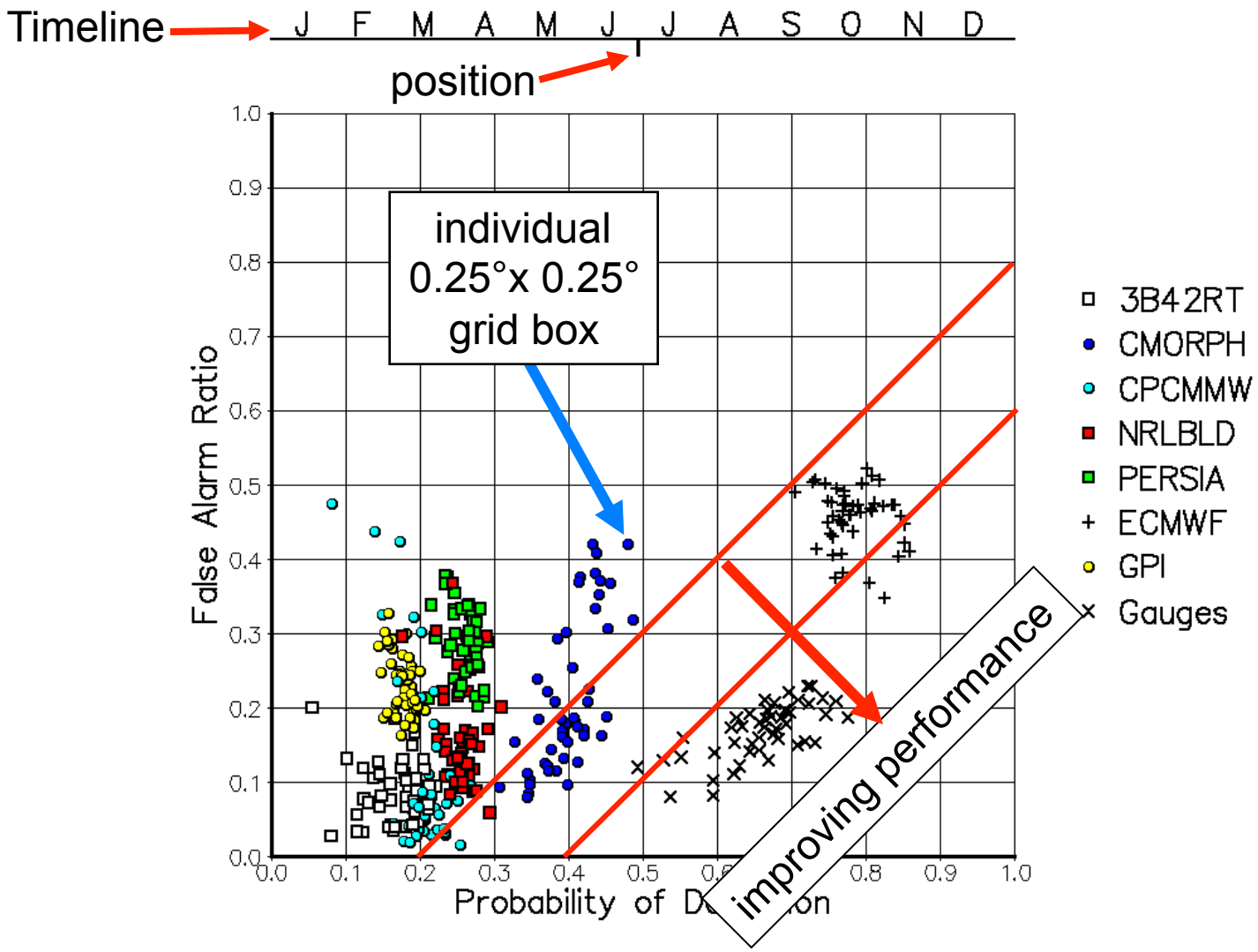
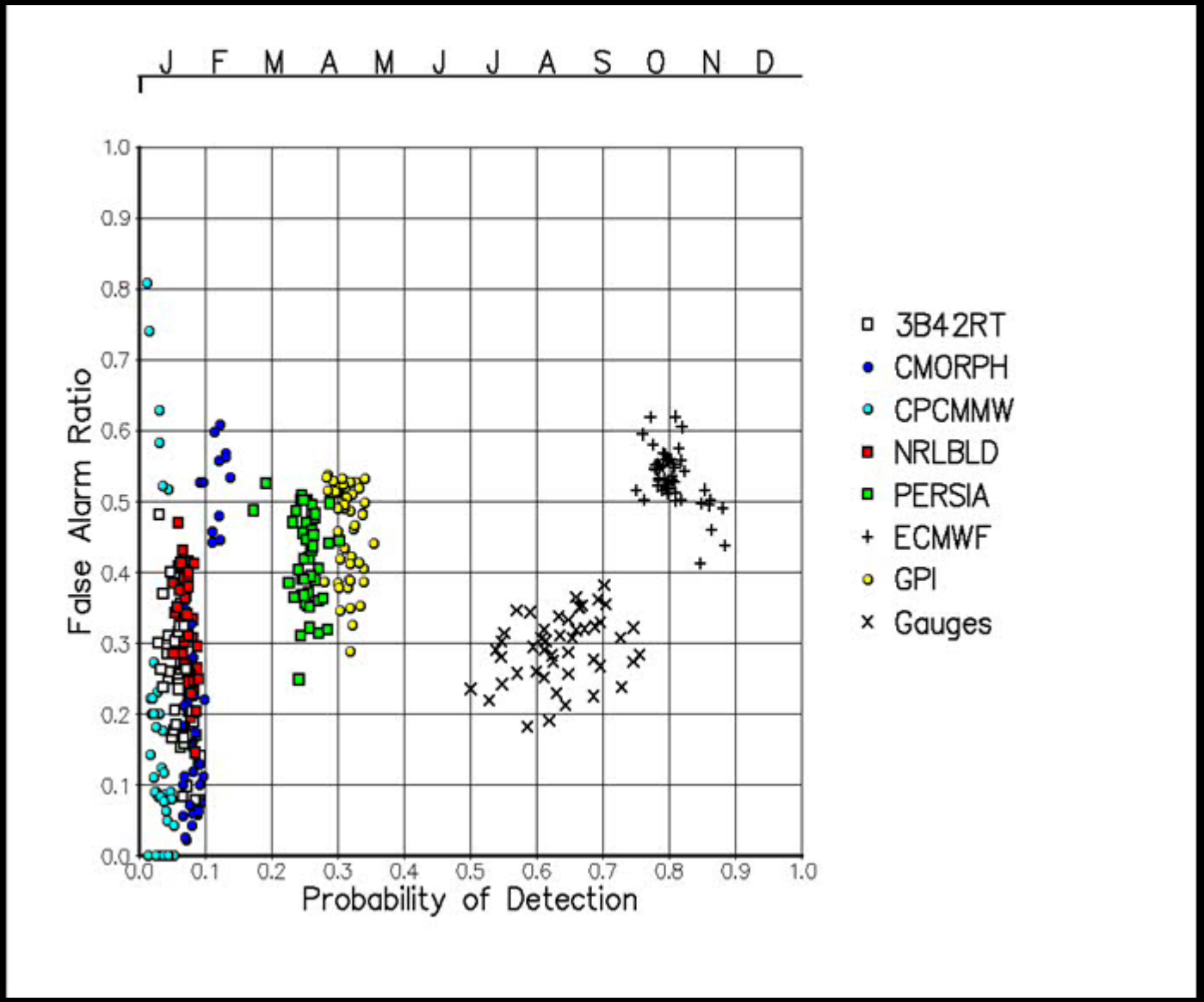
Thank you!

Questions?

chris.kidd@nasa.gov

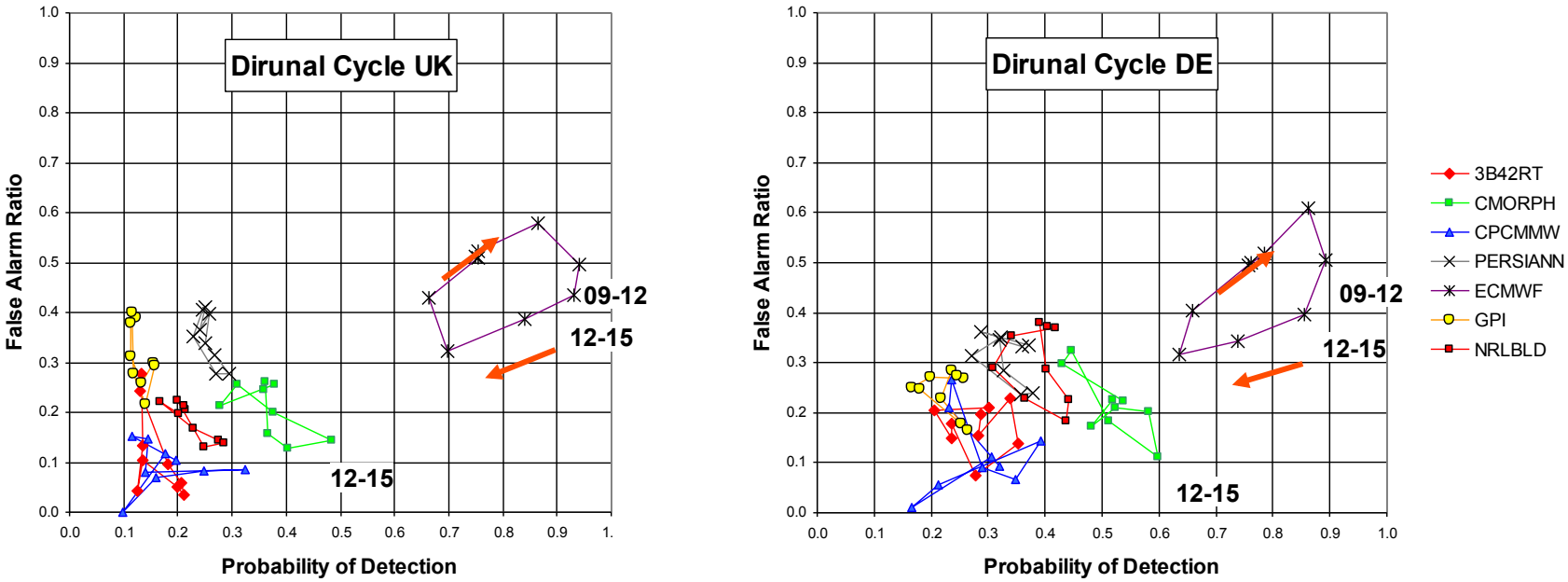
SE England analysis (vs radar)





Performance is spatially consistent

Diurnal statistical performance (JJA)



Generated from 3-hourly accumulations

ECMWF: evident diurnal cycle in performance

CMORPH: over Germany performance in JJA ≈ that of ECMWF

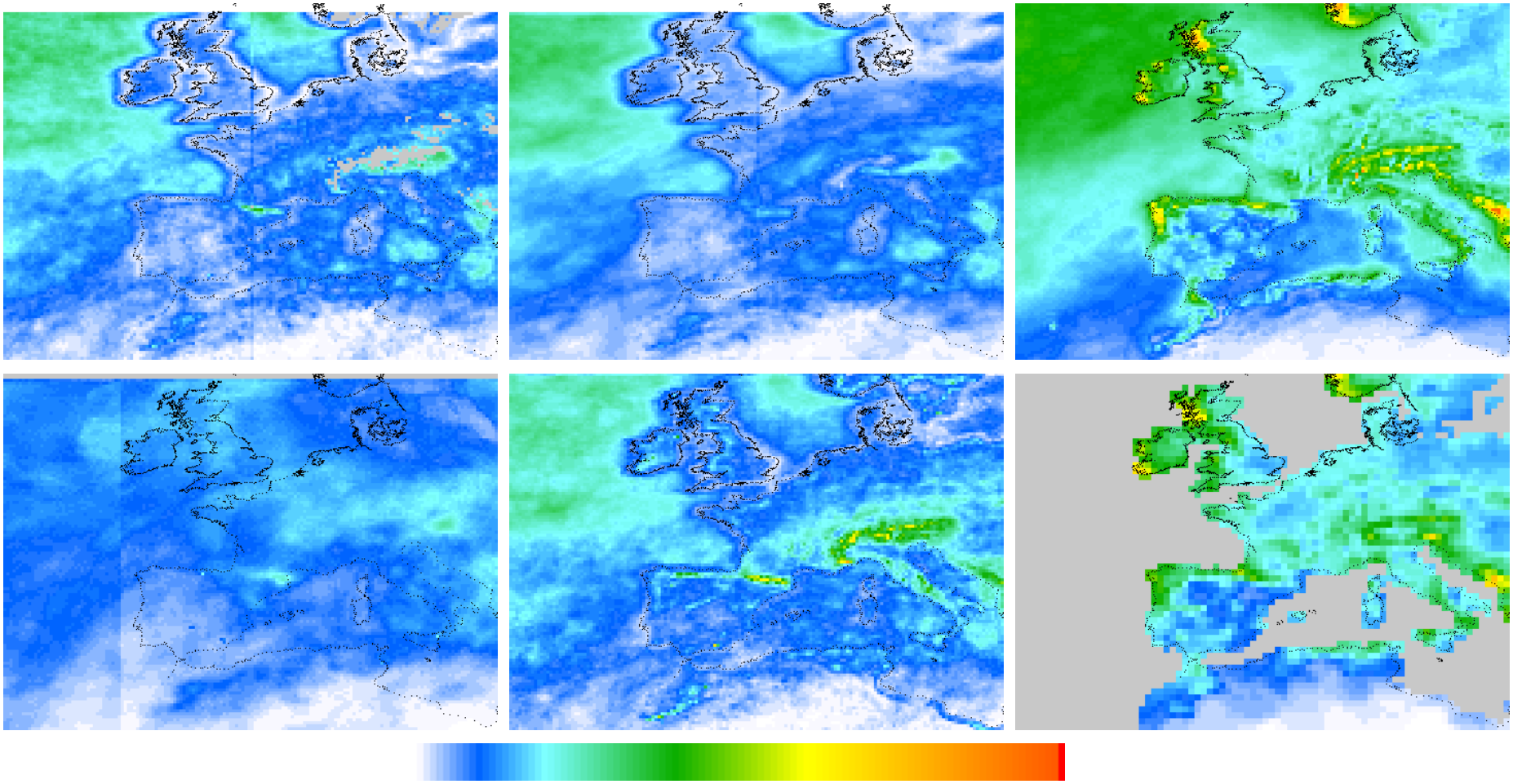
Uncertainties vary temporally (sub-daily) as well as spatially

Surface & Satellite Observing Systems

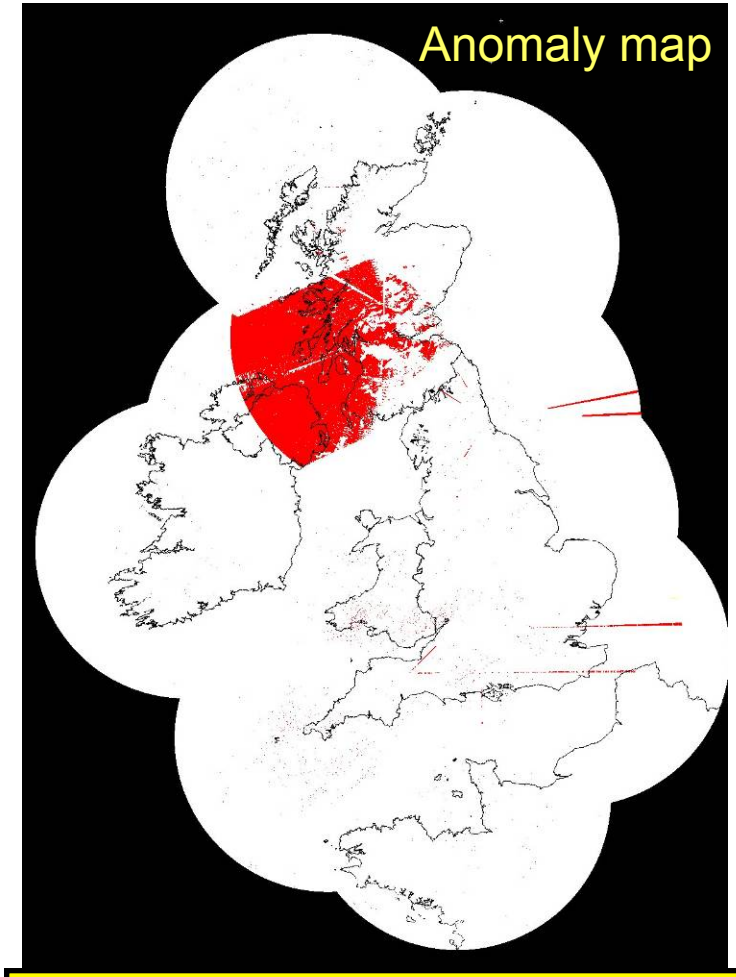
	Instrument	Temporal	Spatial	Notes
Surface	Gauges: accumulation	Variable	Point	Temporal scale dependent upon observation frequency
	Gauges: Tipping Bucket	Quantised	Point	Quantisation of bucket (0.1 or 0.2 mm or 1/100”) and data logger
	Distrometers	Instantaneous	Point	Individual drop measurements
	Micro rain radar	Instantaneous	Point	30 vertical levels
	Weather radar	Instantaneous	Radial	Radial measurements of dBZ converted to a Cartesian grid
Satellite	Visible imagery	Instantaneous	1-4 km	Intermittent (LEO) 15 min sampling (GEO)
	Infrared imagery	Instantaneous	1-4 km	Intermittent (LEO) 15 min sampling (GEO)
	Passive Microwave Imagers	Column	5-25 km	Intermittent sampling (LEO) Resolution = frequency dependent
	Passive Microwave Sounders	Column	16-48 km	Intermittent sampling (LEO) Resolution = frequency/scan position depen.
	Active Microwave (radar)	Instantaneous	5 km	80 vertical levels; Intermittent sampling (LEO)

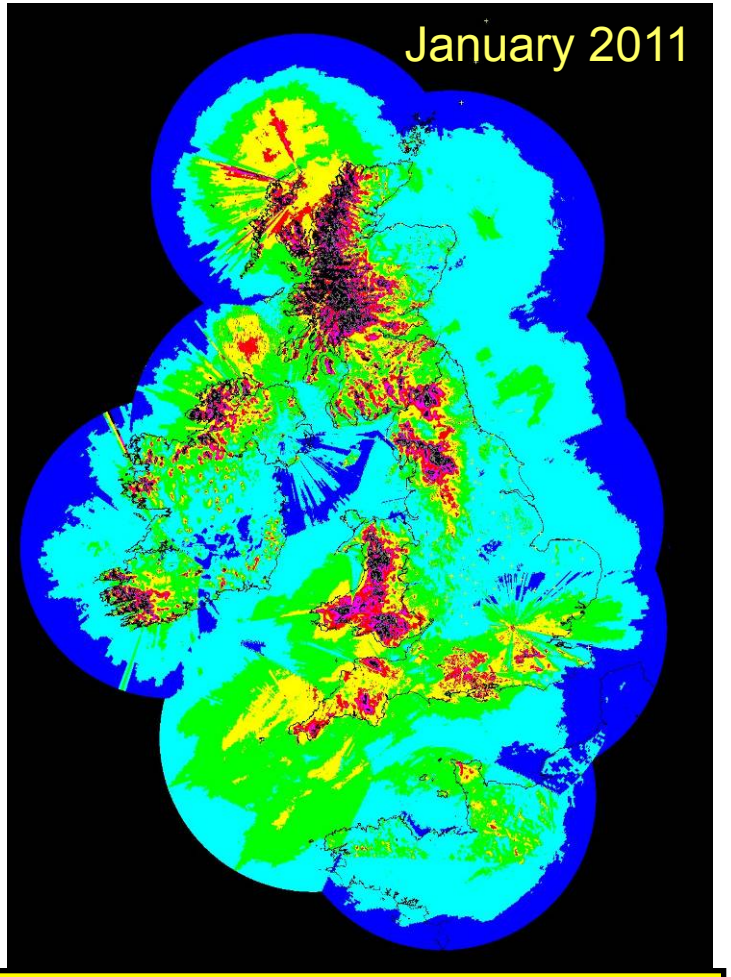
Critically, observations have different spatial/temporal characteristics

Precipitation Products, Europe 2009

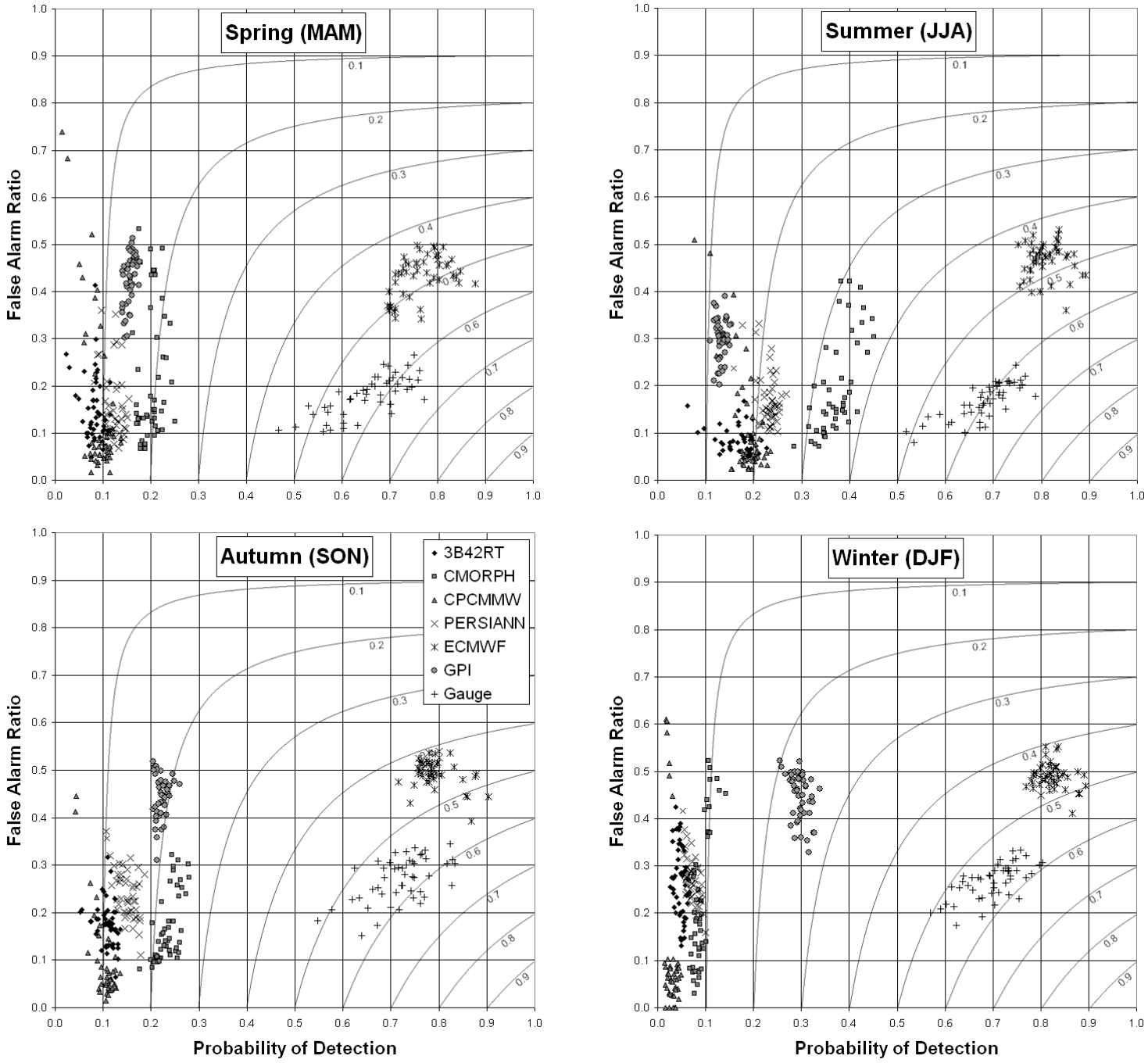


Radar quality-control

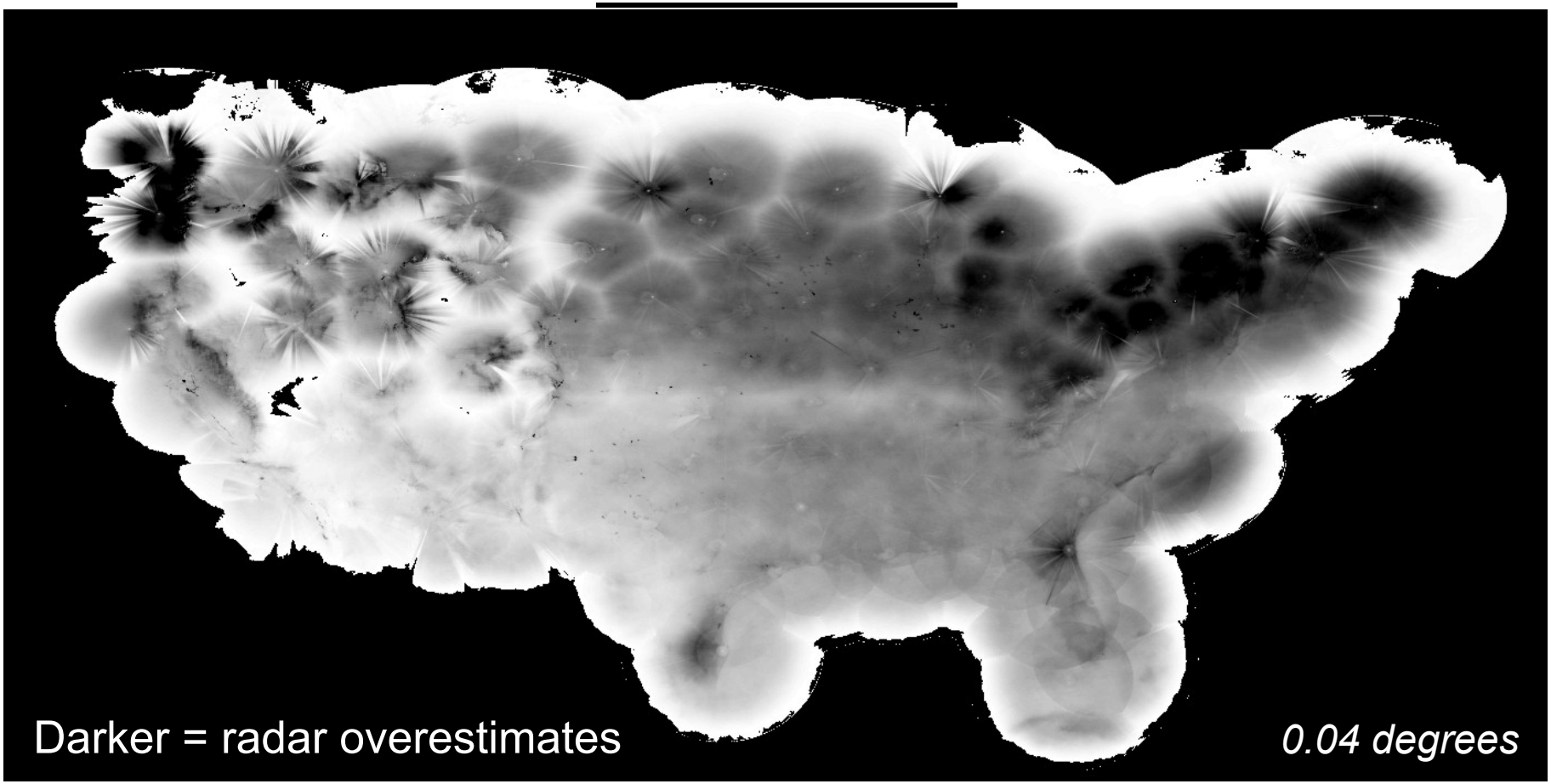




***Operational* QC is not necessarily the same as *research* QC**

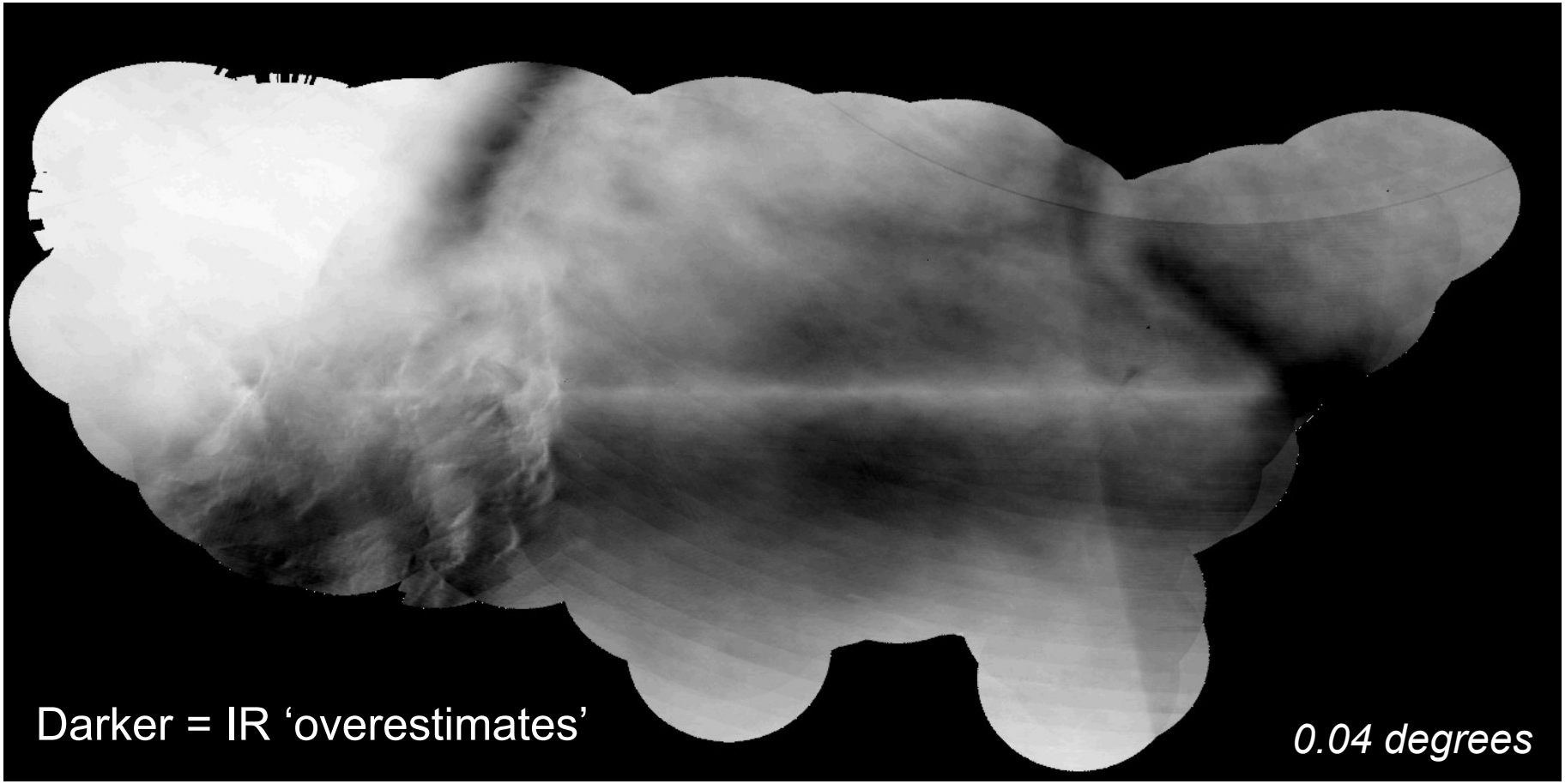

Spring (MAM)
Summer (JJA)
Autumn (SON)
Winter (DJF)
3B42RT
CMORPH
CPCMMW
PERSIANN
ECMWF
GPI
Gauge
False Alarm Ratio
Probability of Detection
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

IR vs NMQ



Global IR data as proxy for rain: radar over/under-estimation

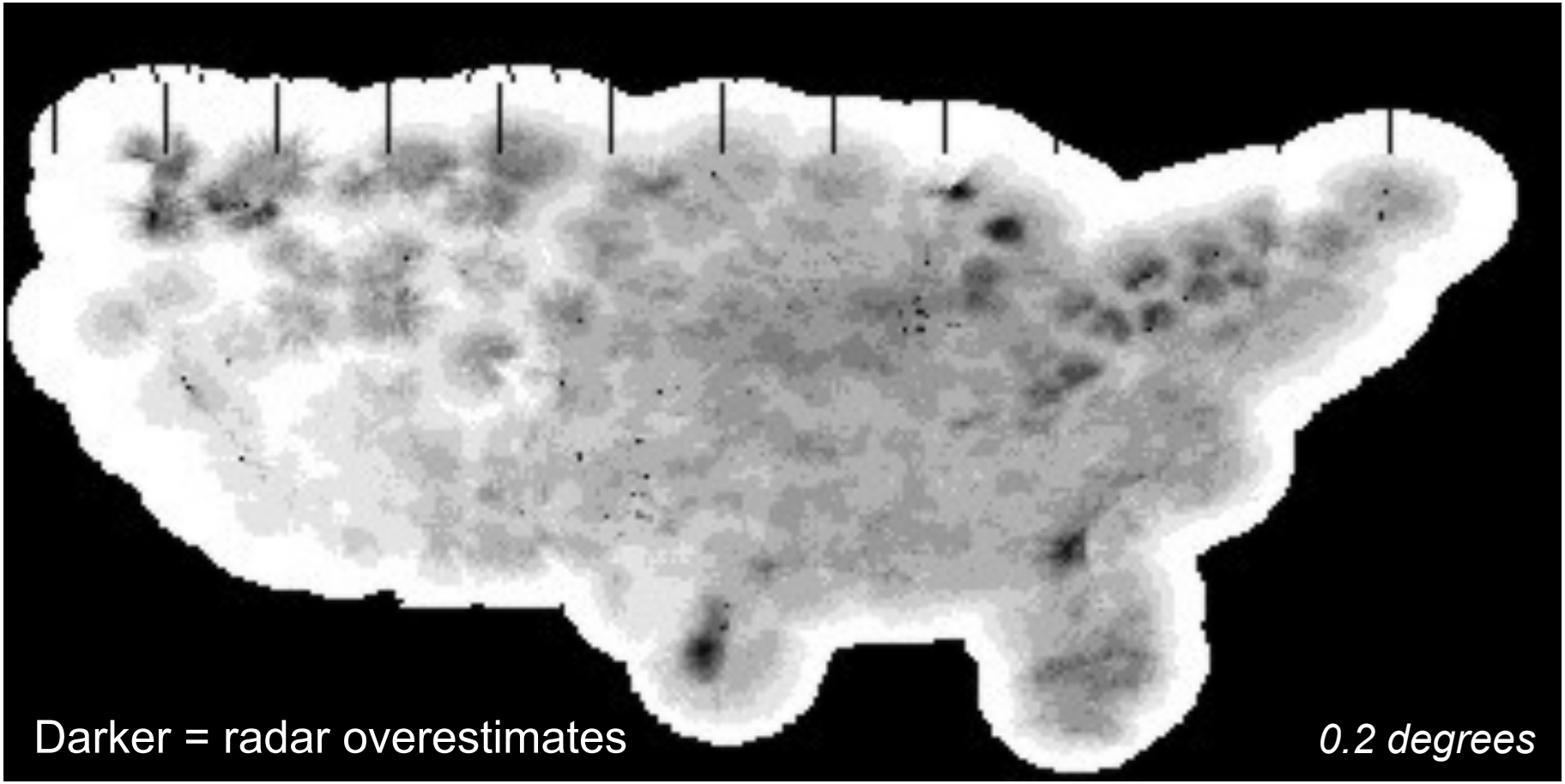
IR vs NMQ



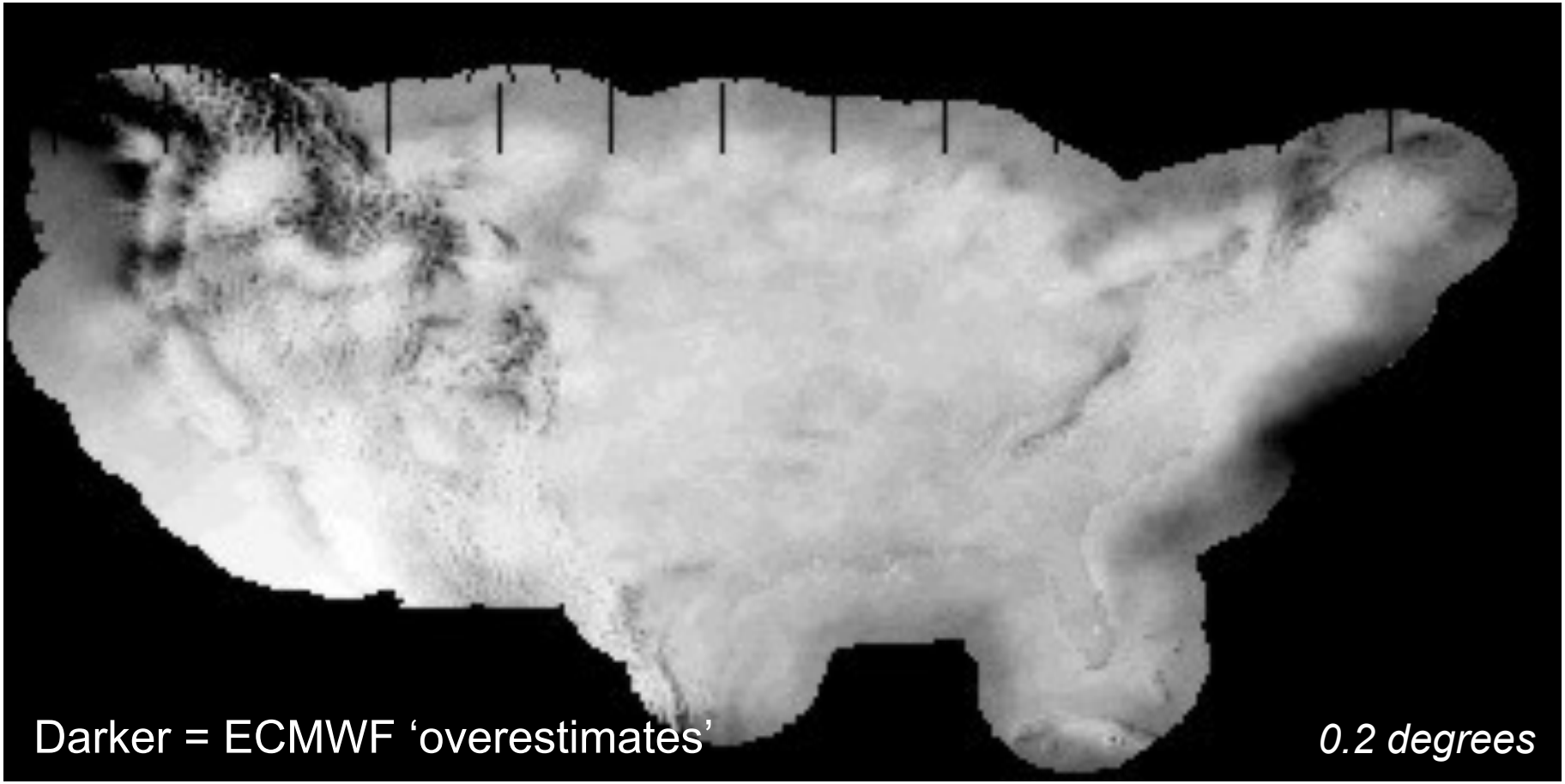
Global IR data as proxy for rain: IR errors/characteristics

NOTE: NMQ is NOT on an equal-area projection!

ECMWF vs NMQ



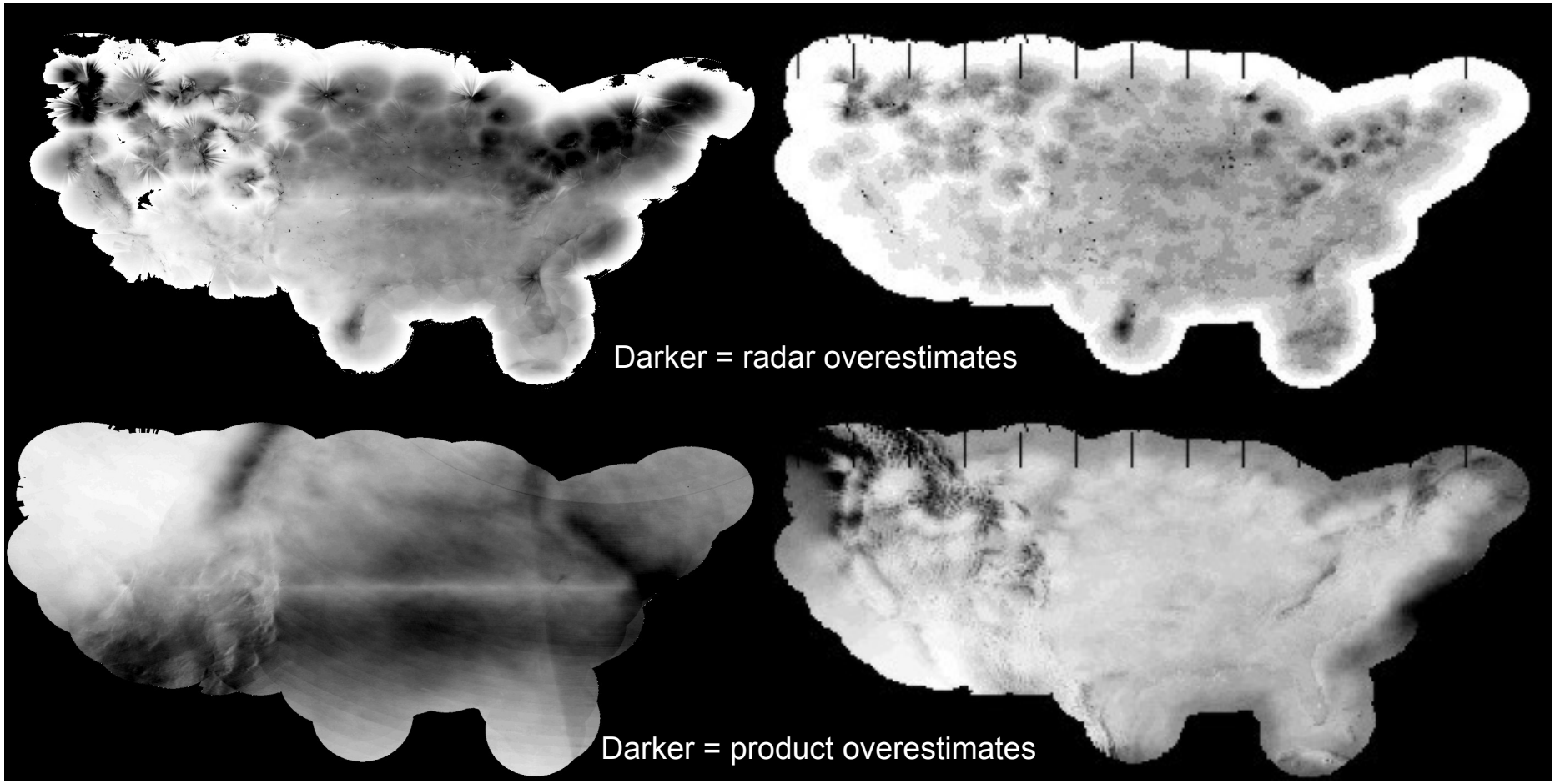
ECMWF vs NMQ



IR & ECMWF vs NMQ

IR comparison

ECMWF comparison



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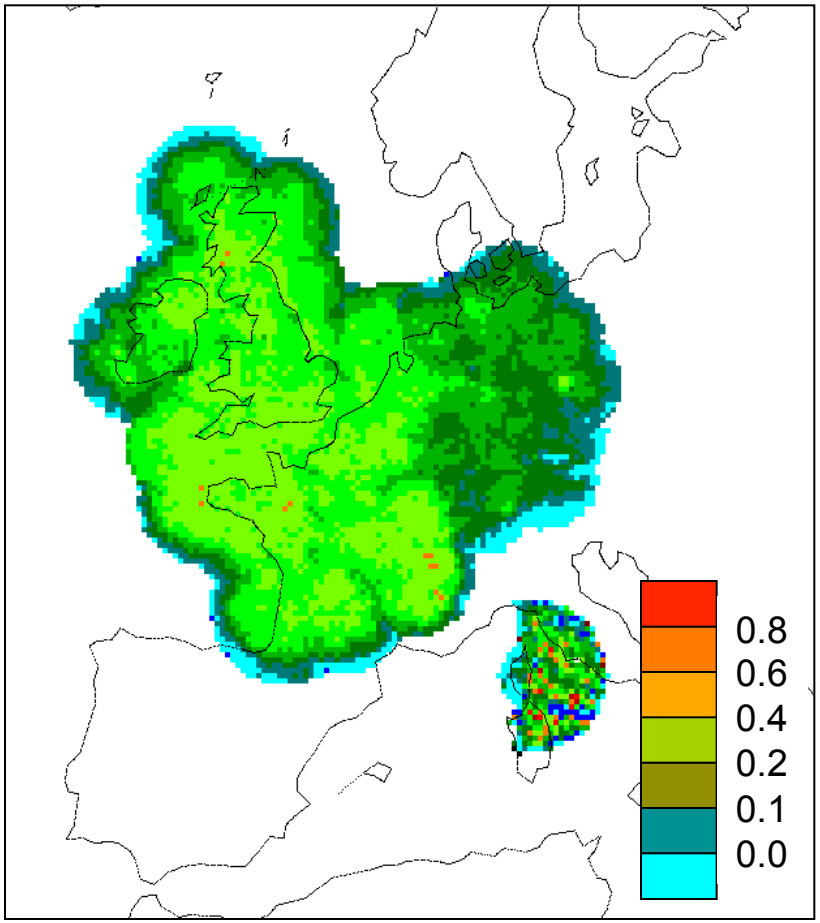

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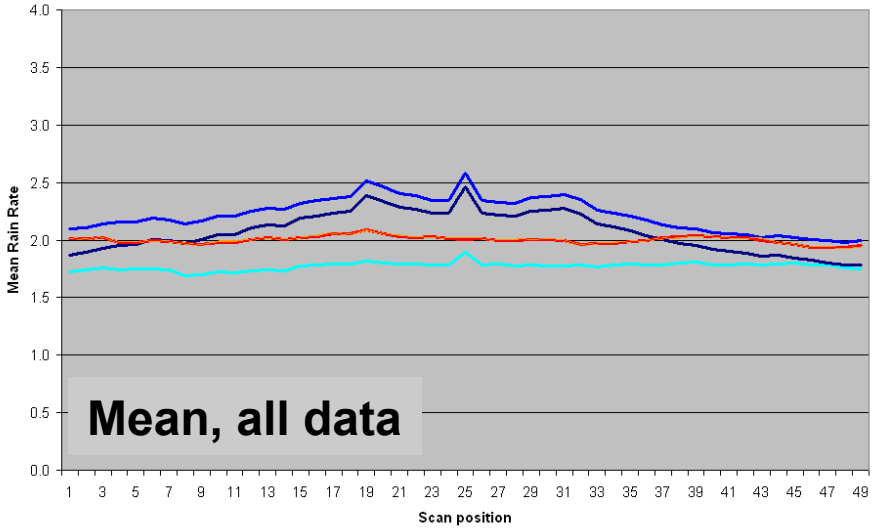
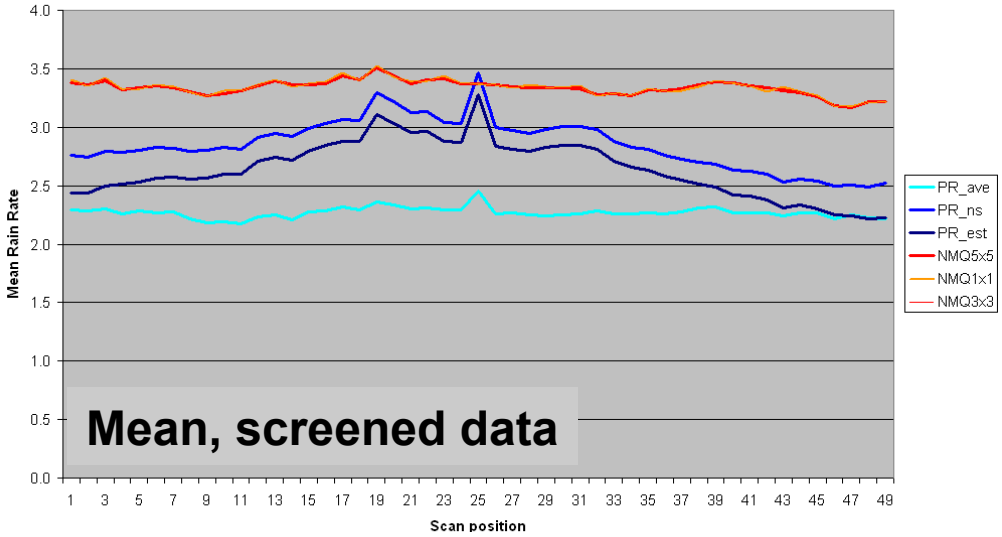
Word maps

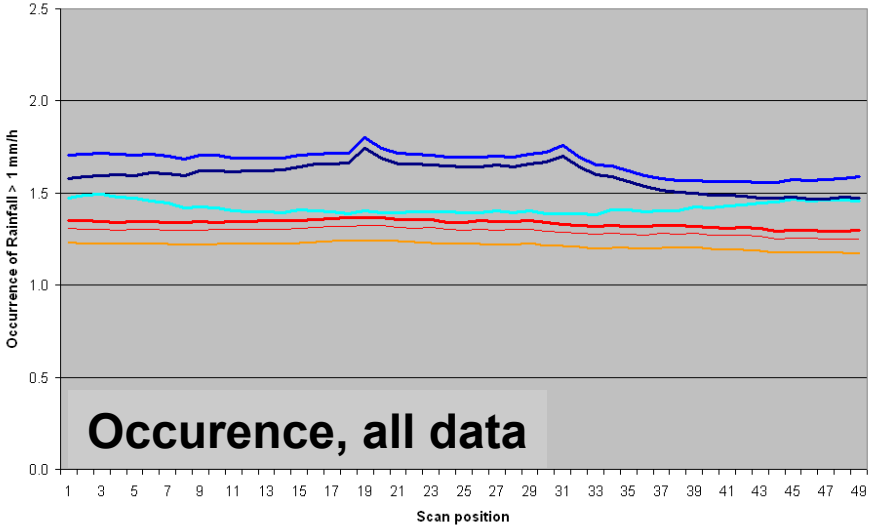

misplay
wrongdoing
fault
computer error
error
mistake
erroneous belief
erroneousness

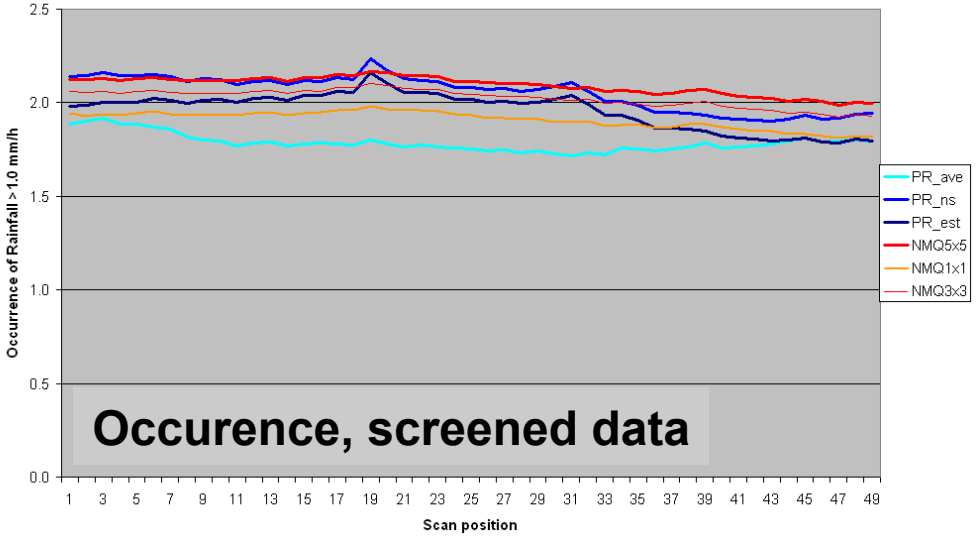

undependable
unreliable
unsettled
changeable
ambiguous
unsealed
sure thing
foregone conclusion
certain
certainty
incertain
uncertain
unsure
undetermined
indeterminate
indefinite
chancy
flukey
fluky
iffy
up in the air
unpredictable
contingent

PR vs NMQ


Mean Rain Rate
Scan position
Mean, all data


Mean Rain Rate
Scan position
PR_ave
PR_ns
PR_est
NMQ5x5
NMQ1x1
NMQ3x3
Mean, screened data


Occurrence of Rainfall > 1 mm/h
Scan position
Occurence, all data


Occurrence of Rainfall >1.0 mm/h
Scan position
PR_ave
PR_ns
PR_est
NMQ5x5
NMQ1x1
NMQ3x3
Occurence, screened data