Evaluation of Satellite Rainfall Estimates over Arid Regions

Presented by:

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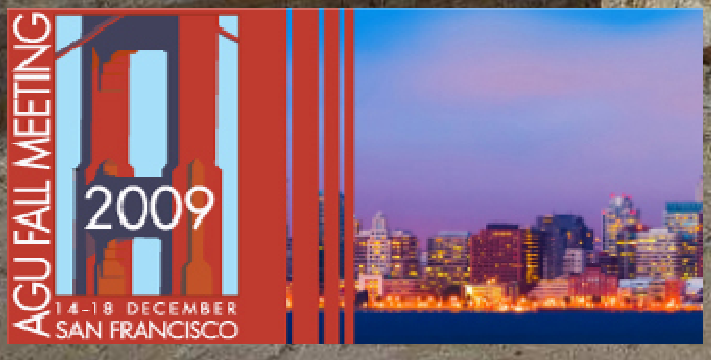

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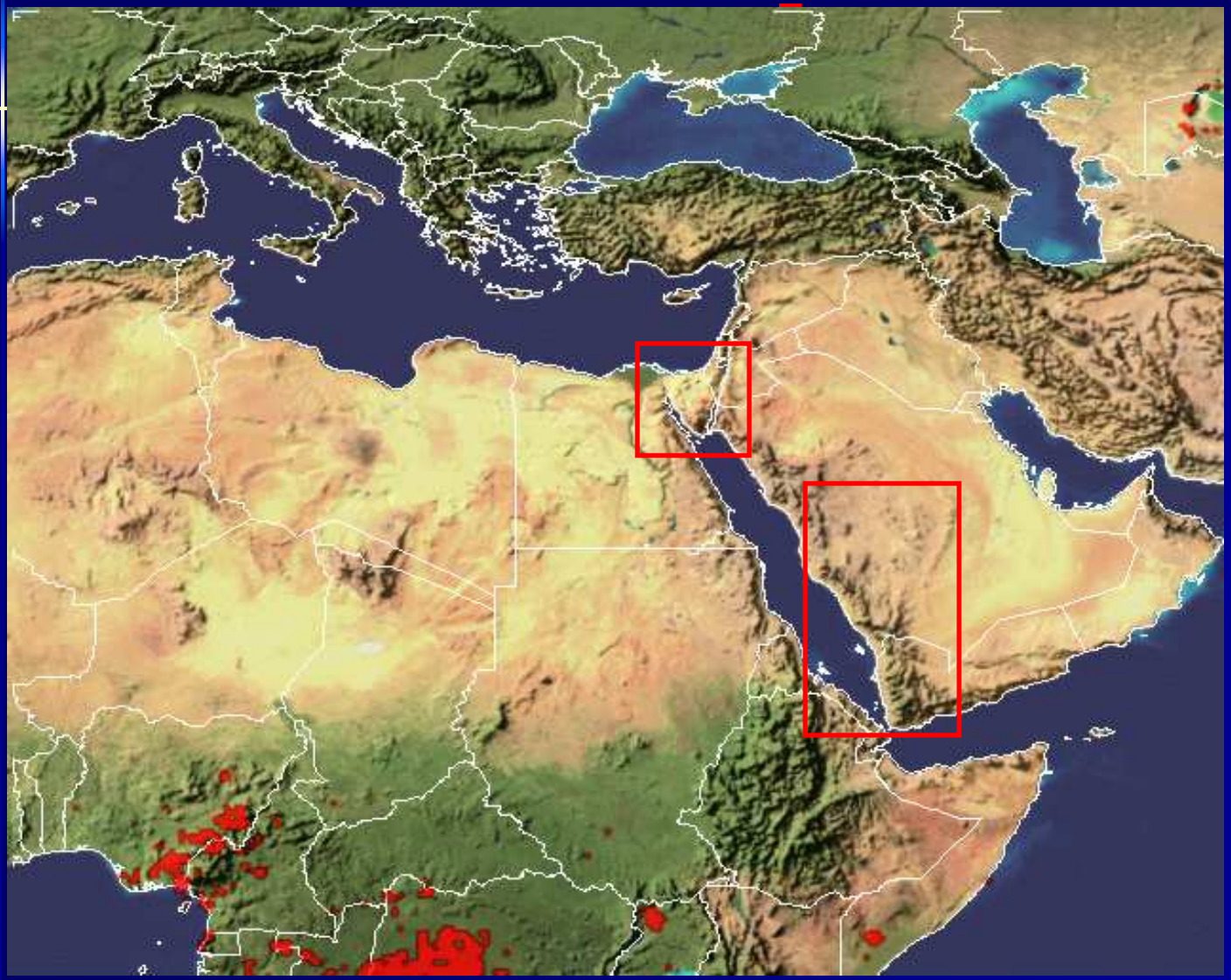
Rainfall Hazards and Benefits

- Arid and Semi-Arid regions are occasionally subject to heavy rainfall events
- Rainfall-triggered flash floods threaten infrastructure and socio-economical developments in these regions
- Rainfall also represent a potential source for non-conventional fresh water

Rainfall Monitoring in Arid/Semi-Arid Areas

Study Sites

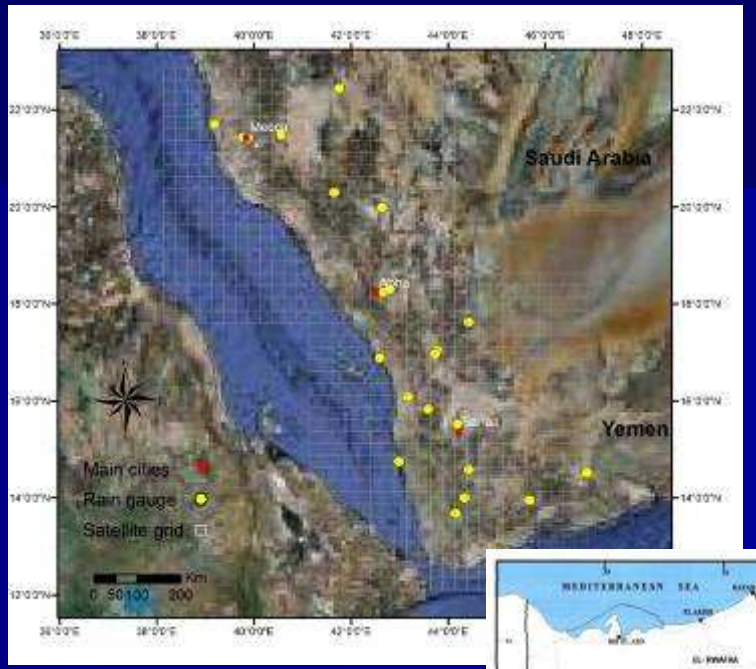


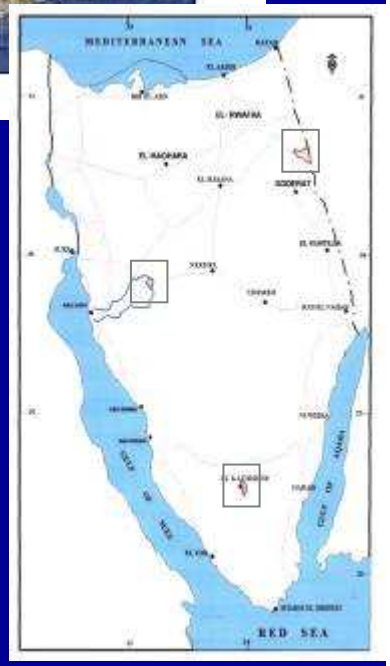
Satellite-Rainfall Products:

- TRMM Multi-sensor Estimates (TMPA)
  - $0.25^\circ \times 0.25^\circ$
  - 3-hourly resolution
- CMORPH
  - 8 x 8 km^2
  - 30 min
- Hydroestimator
  - 4 x 4 km^2
  - Hourly

Very limited rain gauge dataset

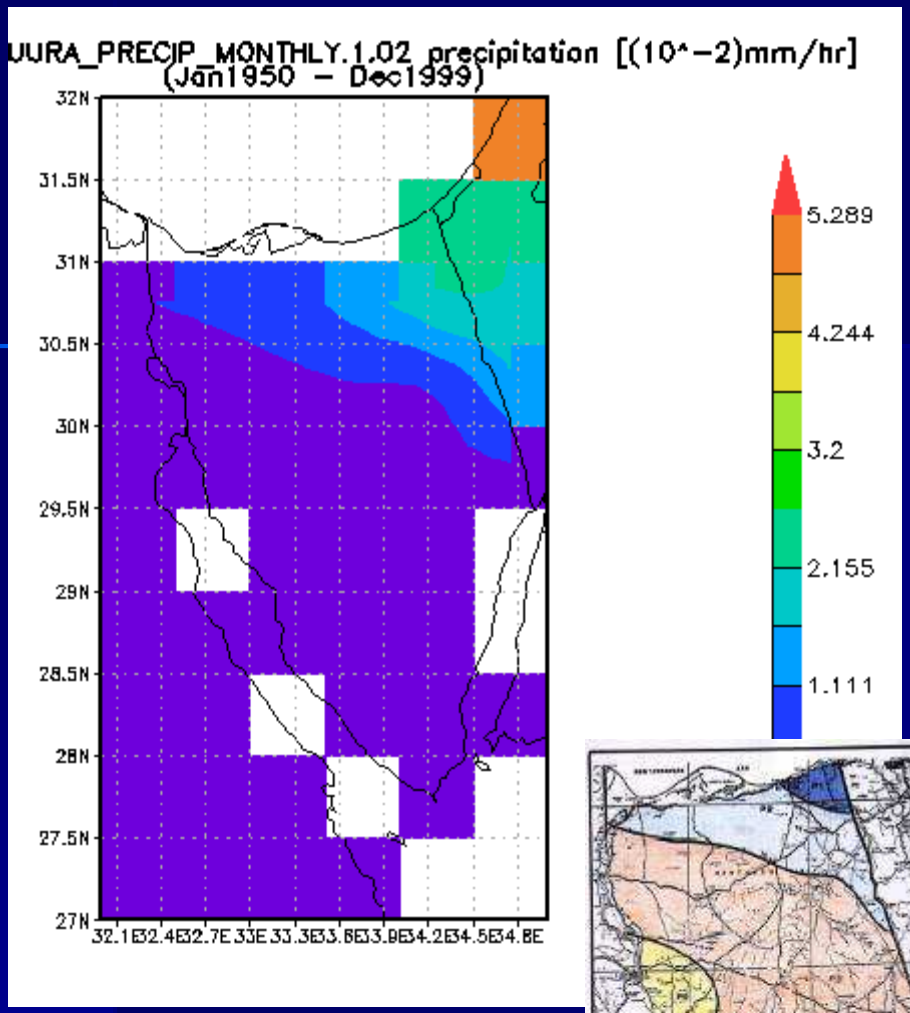
- Daily & Monthly rain gauges
- Acquired from NCDC archives
- Data quality unknown

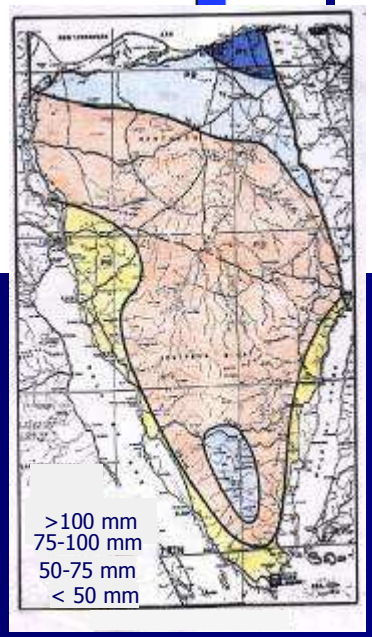


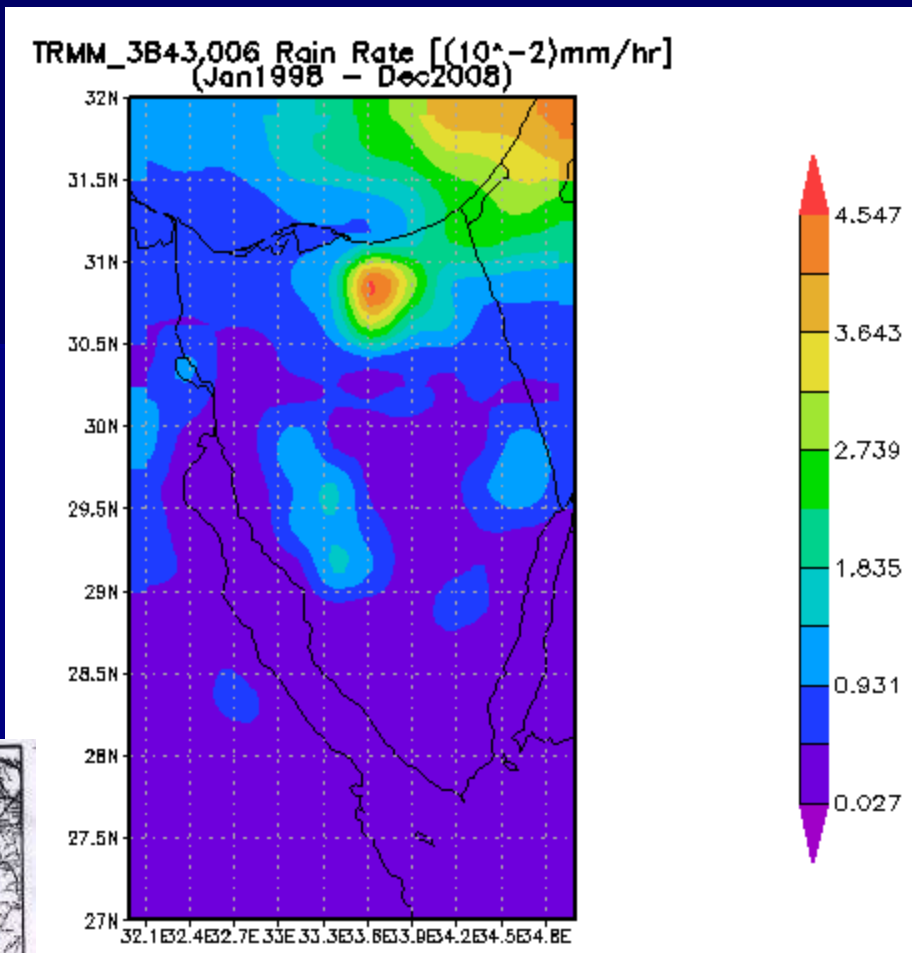


Evaluation Methods

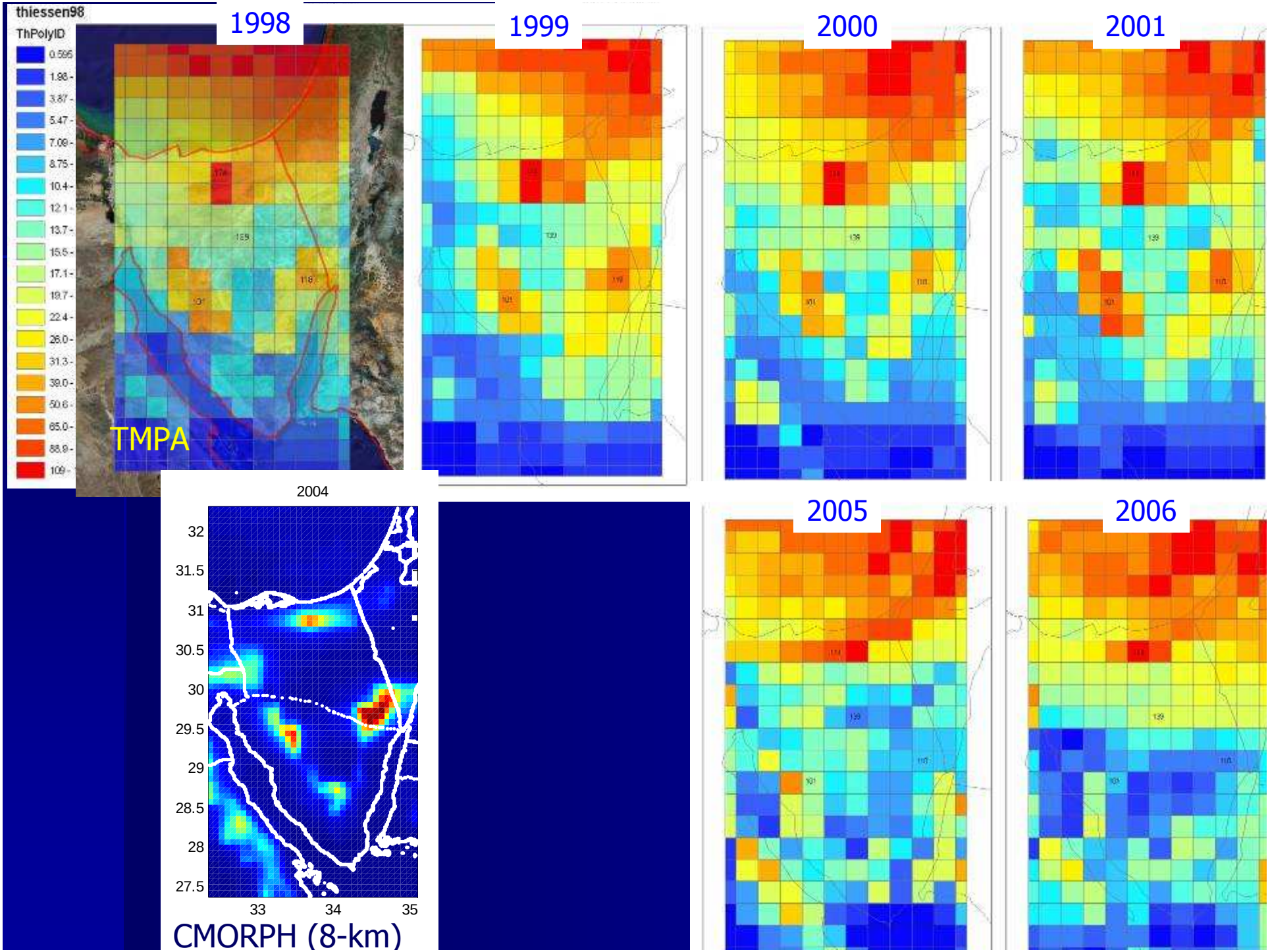
- Examination of long-term spatial and temporal rainfall distribution
- Product–gauge comparisons at coarse scales (monthly/storm scales/daily)
- Analysis of a recent extreme event



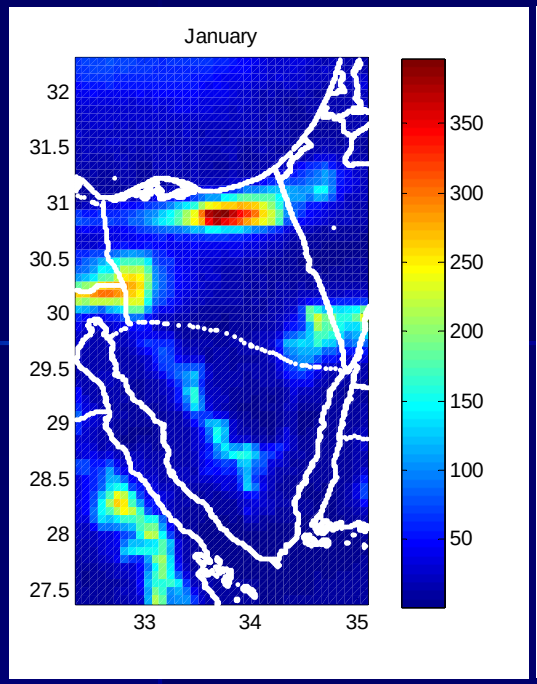


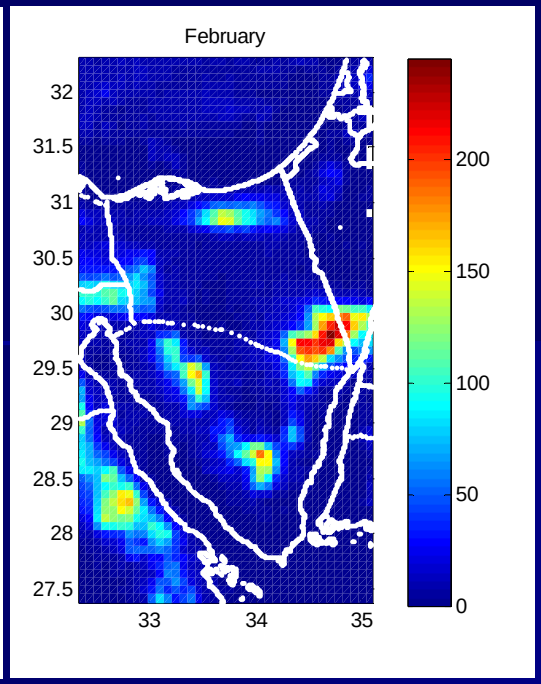


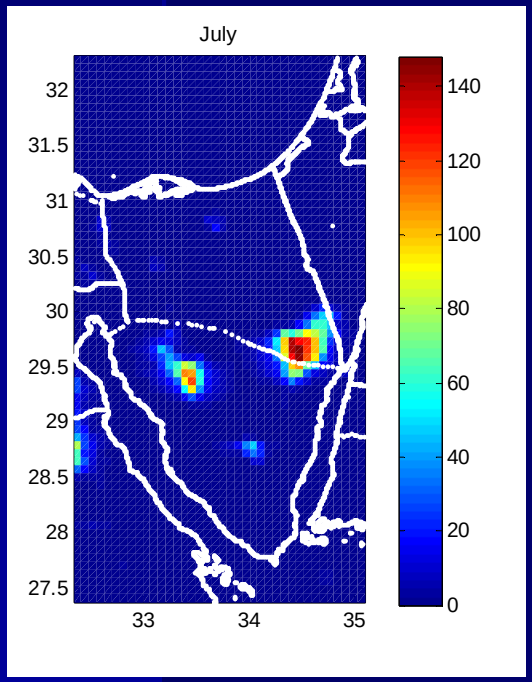
Monthly Willmott and Matsuura Global Precipitation (1950 - 1999)

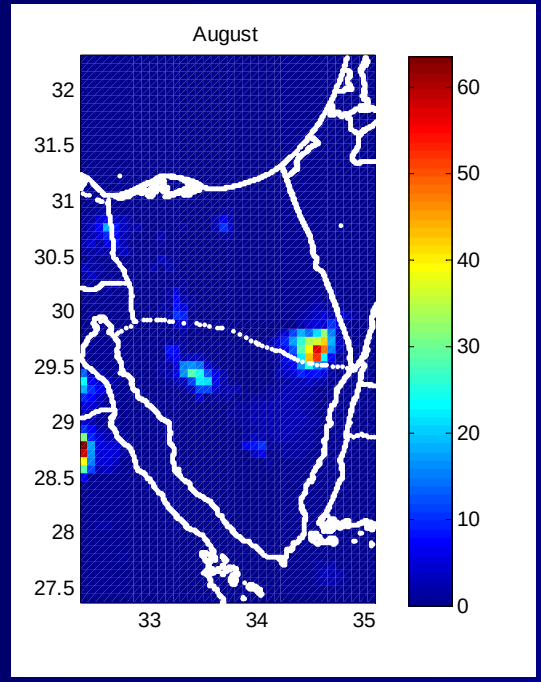

thiessen98
ThPolyID
0.595
1.98
3.87
5.47
7.09
8.75
10.4
12.1
13.7
15.5
17.1
18.7
22.4
26.0
31.3
39.0
50.6
65.0
88.9
109
1998
TMPA
1999
2000
2001
2004
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
33
34
35
CMORPH (8-km)
2005
2006

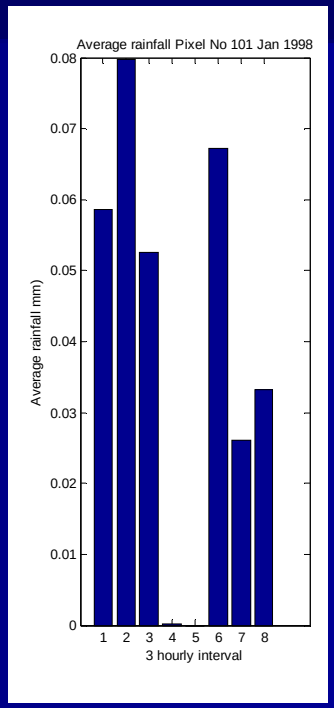
CMORPH 8-km

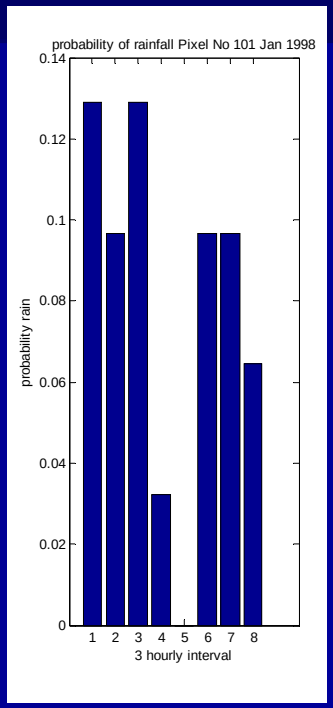

January
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
33
34
35
350
300
250
200
150
100
50

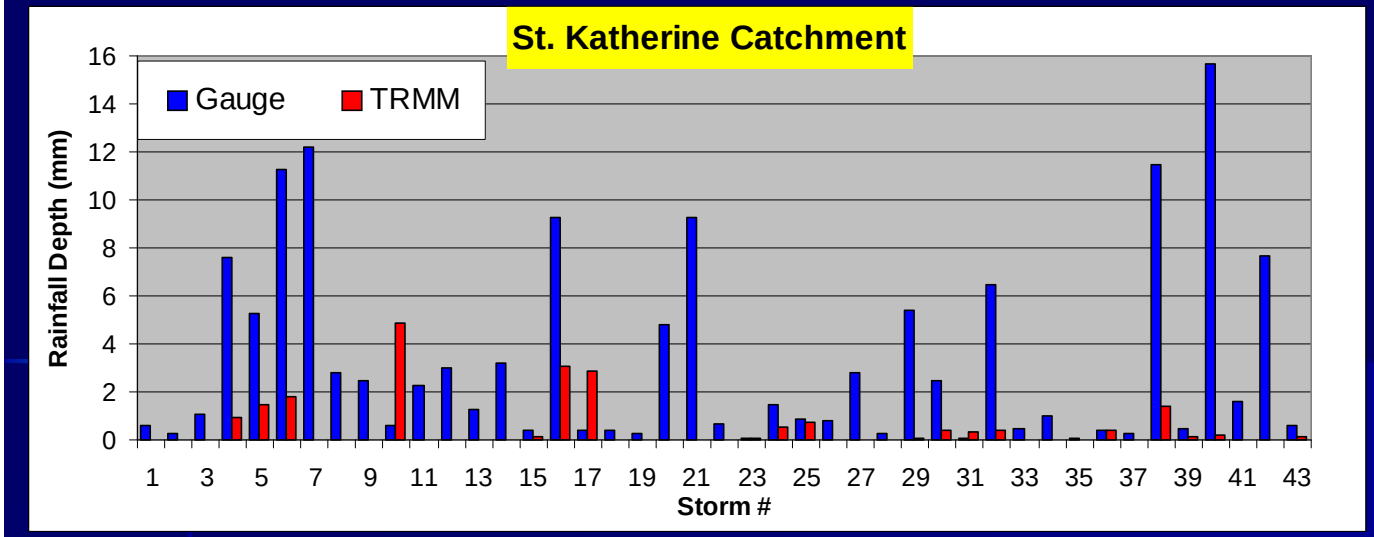

February
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
33
34
35
200
150
100
50
0

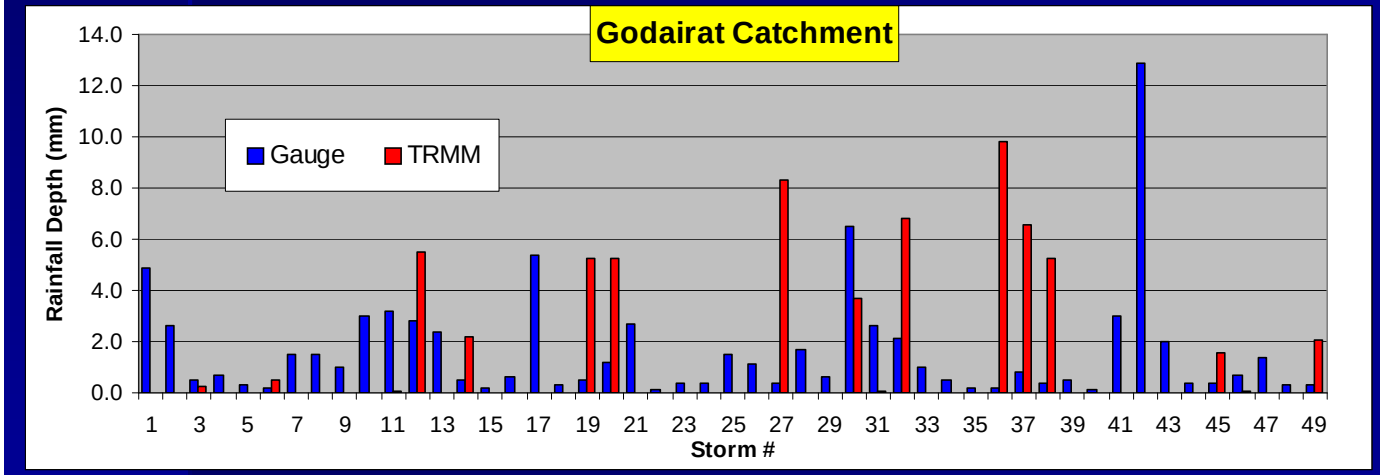

July
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
33
34
35
140
120
100
80
60
40
20
0

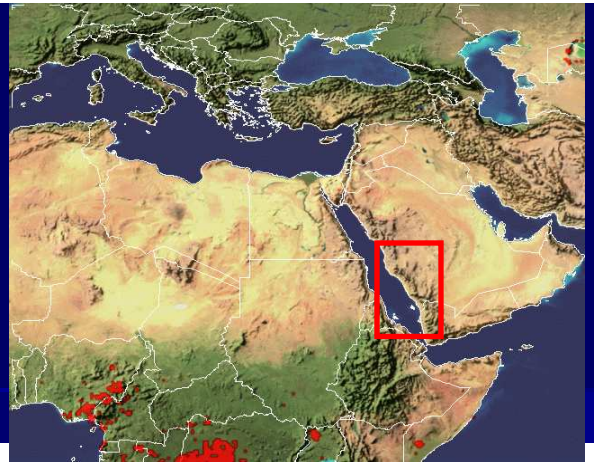

August
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
33
34
35
60
50
40
30
20
10
0


Average rainfall Pixel No 101 Jan 1998
Average rainfall mm)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1 2 3 4 5 6 7 8
3 hourly interval

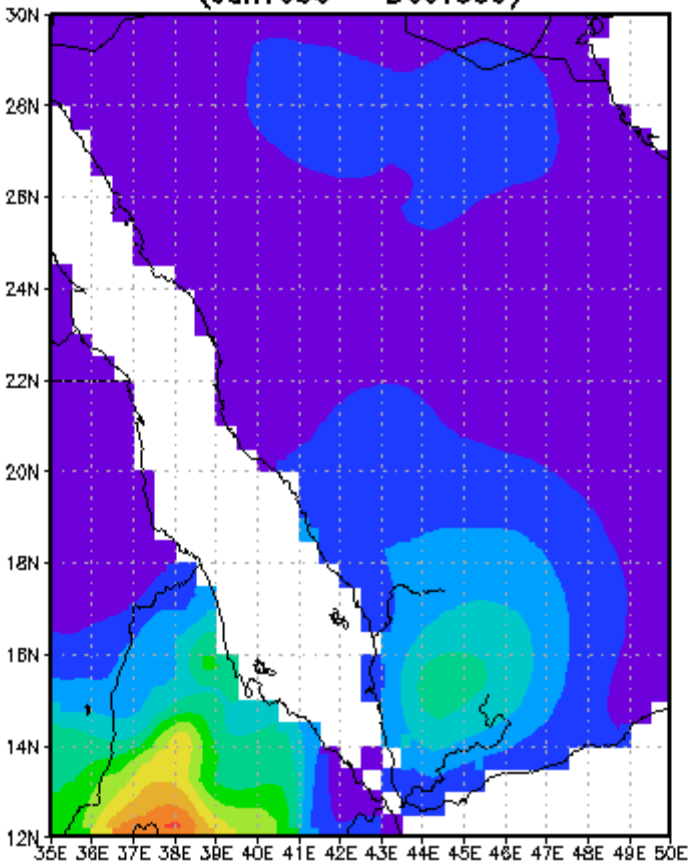

probability of rainfall Pixel No 101 Jan 1998
probability rain
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8
3 hourly interval


St. Katherine Catchment
Gauge
TRMM
Rainfall Depth (mm)
0
2
4
6
8
10
12
14
16
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
Storm #

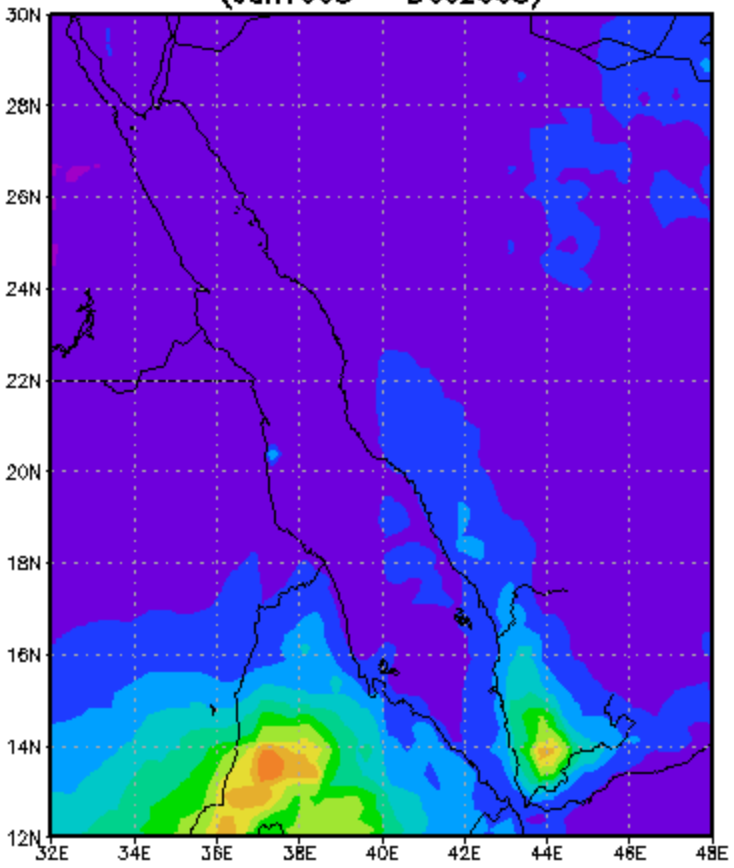

Godairat Catchment
Gauge
TRMM
Rainfall Depth (mm)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
Storm #

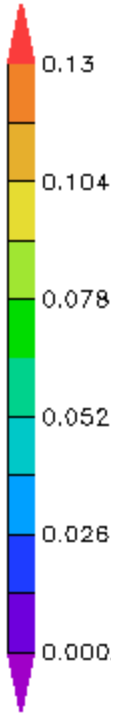


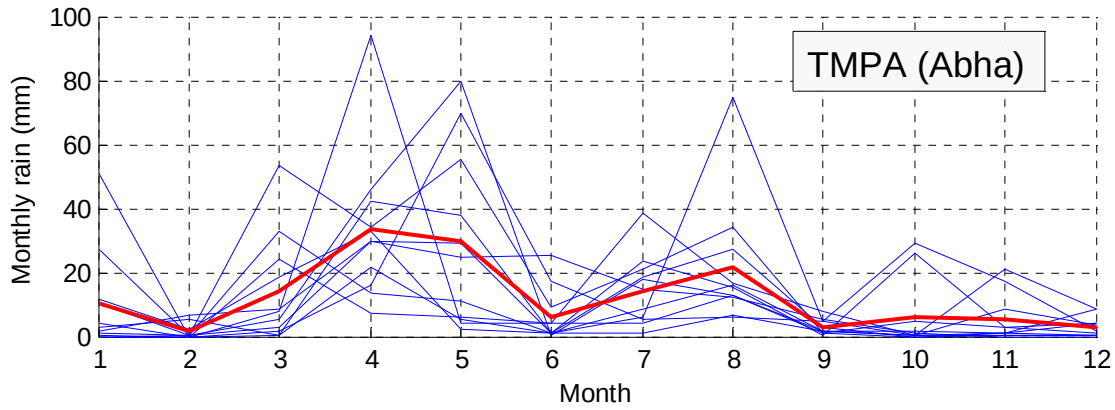
WILLMOTT_MATSUURA_PRECIP_MONTHLY.1.02 precipitation [mm/
(Jan1950 – Dec1999)

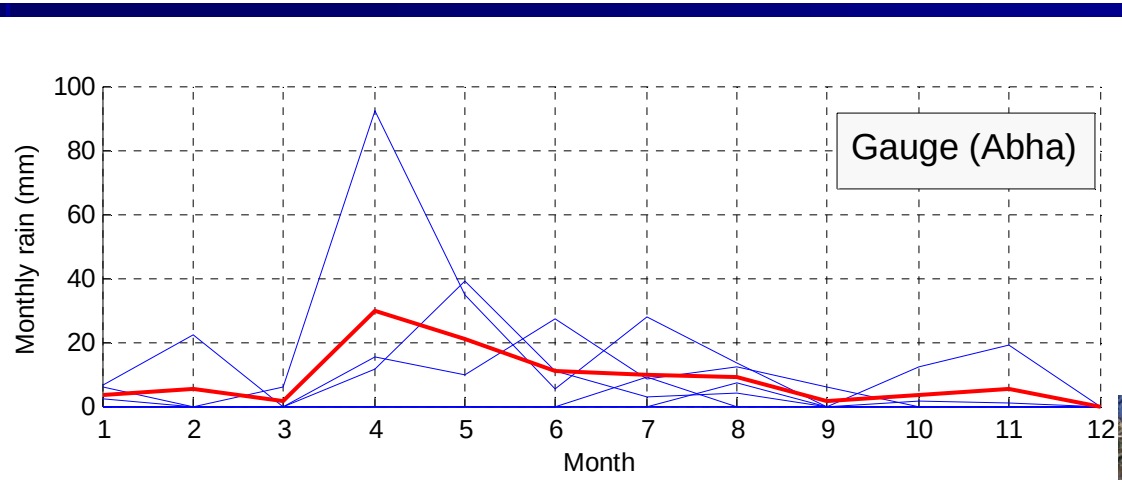


TRMM_3B43.006 Rain Rate [mm/hr]
(Jan1998 – Dec2008)

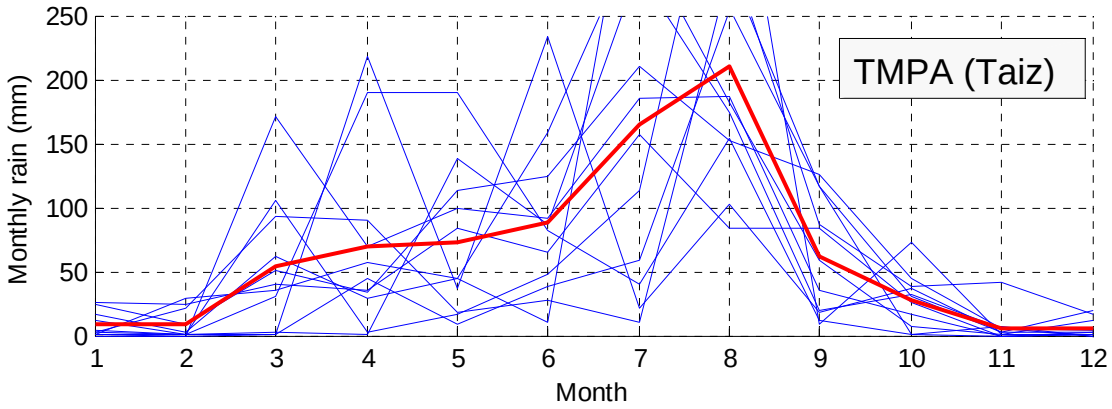


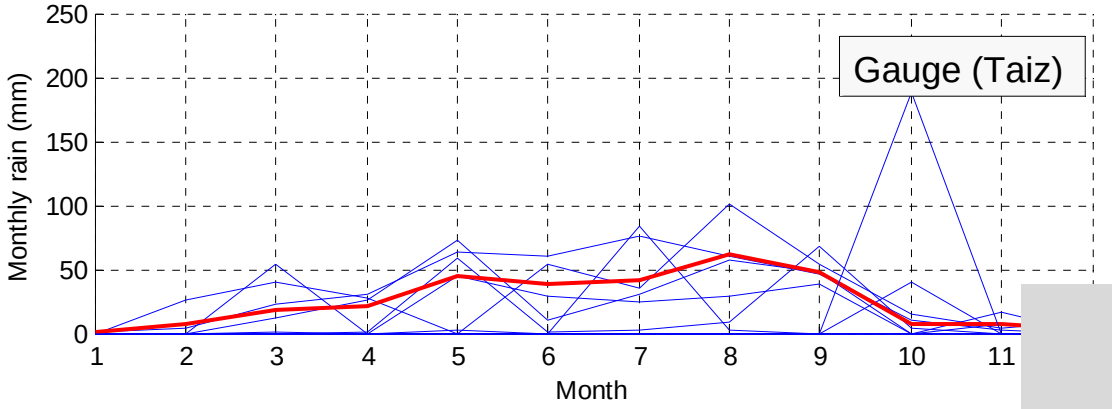



TMPA (Abha)
Monthly rain (mm)
Month
0
20
40
60
80
100
1
2
3
4
5
6
7
8
9
10
11
12


Gauge (Abha)
Monthly rain (mm)
Month
0
20
40
60
80
100
1
2
3
4
5
6
7
8
9
10
11
12


Jeddah
Makkah (Mecca)
Port Sudan
Khamis Mushayt
Jizan
Eritrea
Sana'a
Yemen
Aden





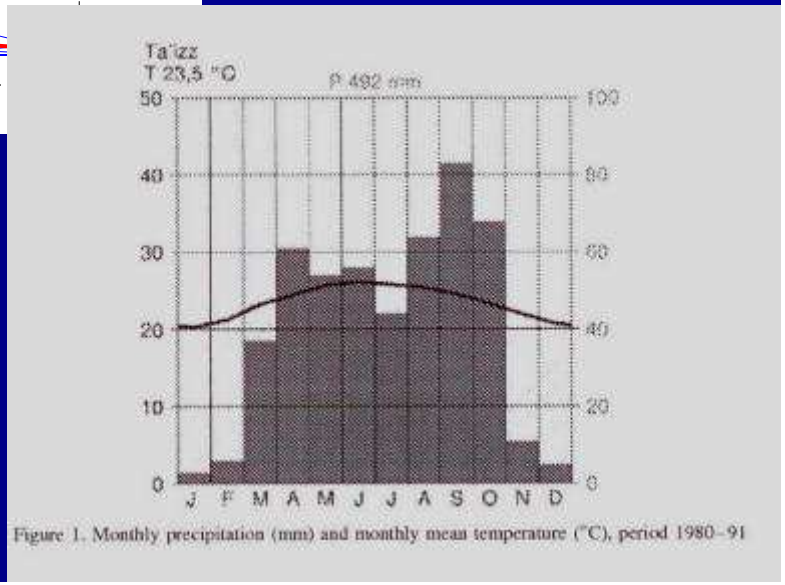
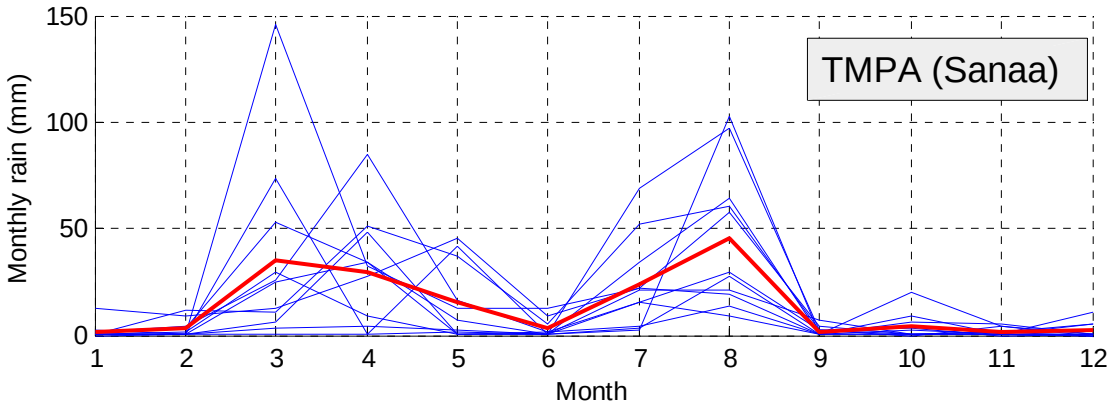
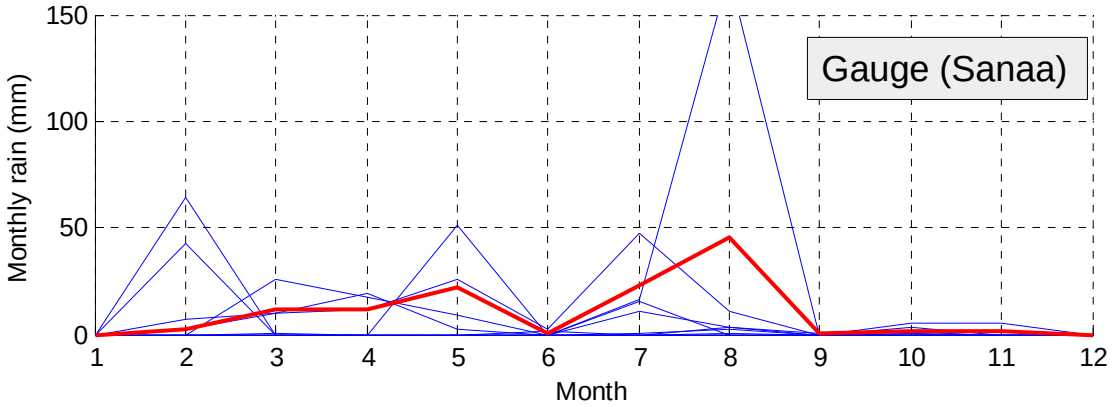


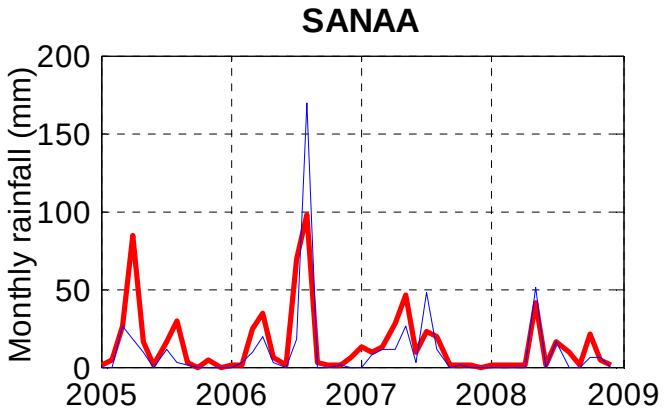
Figure 1. Monthly precipitation (mm) and monthly mean temperature (°C), period 1980–91

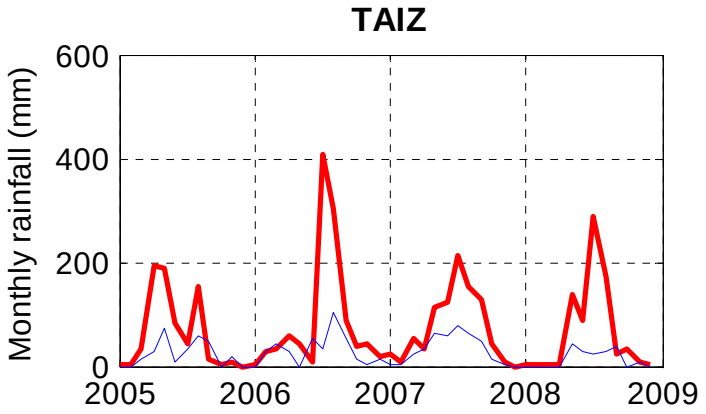

TMPA (Sanaa)
Monthly rain (mm)
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

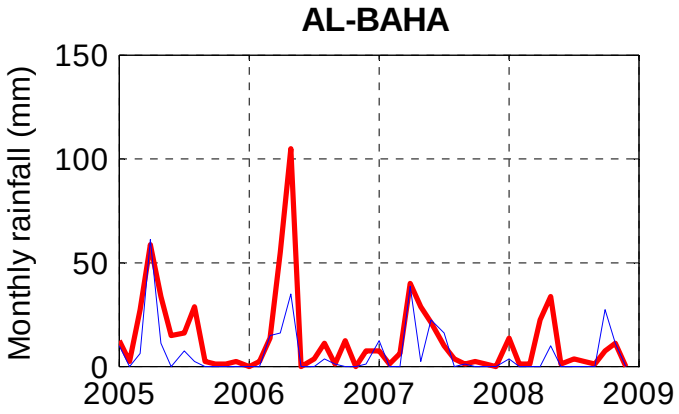

Gauge (Sanaa)
Monthly rain (mm)
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Month

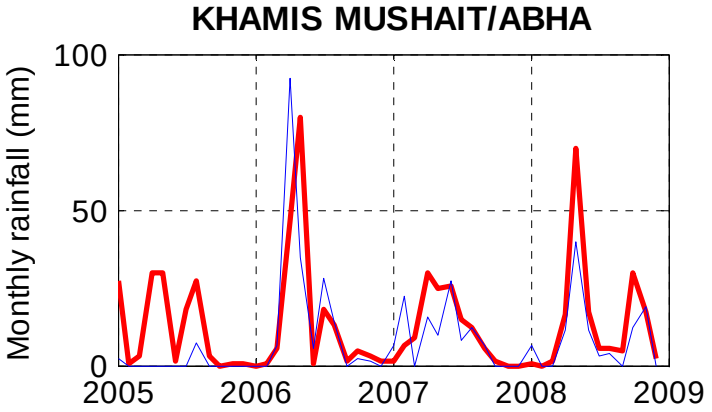

Jeddah
Makkah (Mecca)
Port Sudan
Khamis Mushayt
Jizan
Eritrea
Sana'
Yemen
Aksum
Adan


Sana'a Airport
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

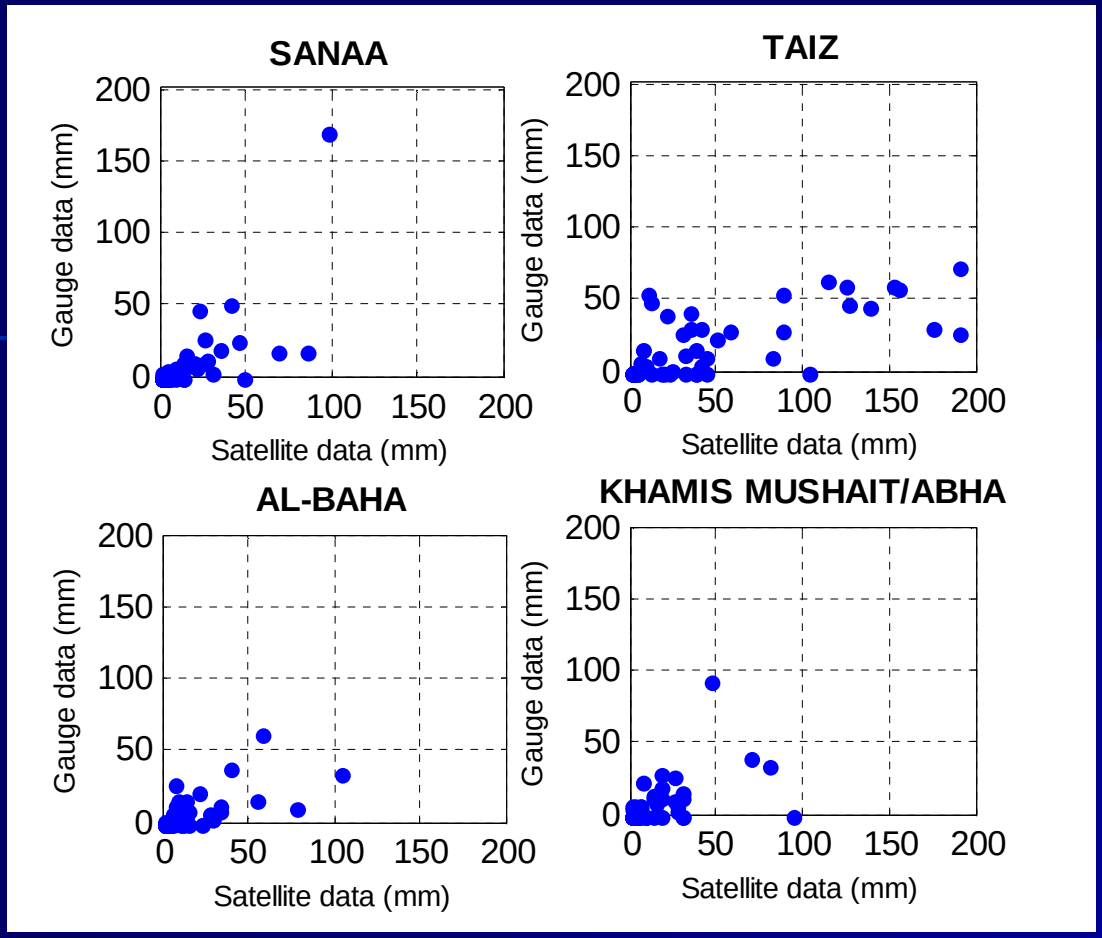








- Monthly rainfall from TRMM-TMPA satellite estimates versus the corresponding monthly rain gauge observations over four stations in Saudi Arabia and Yemen.

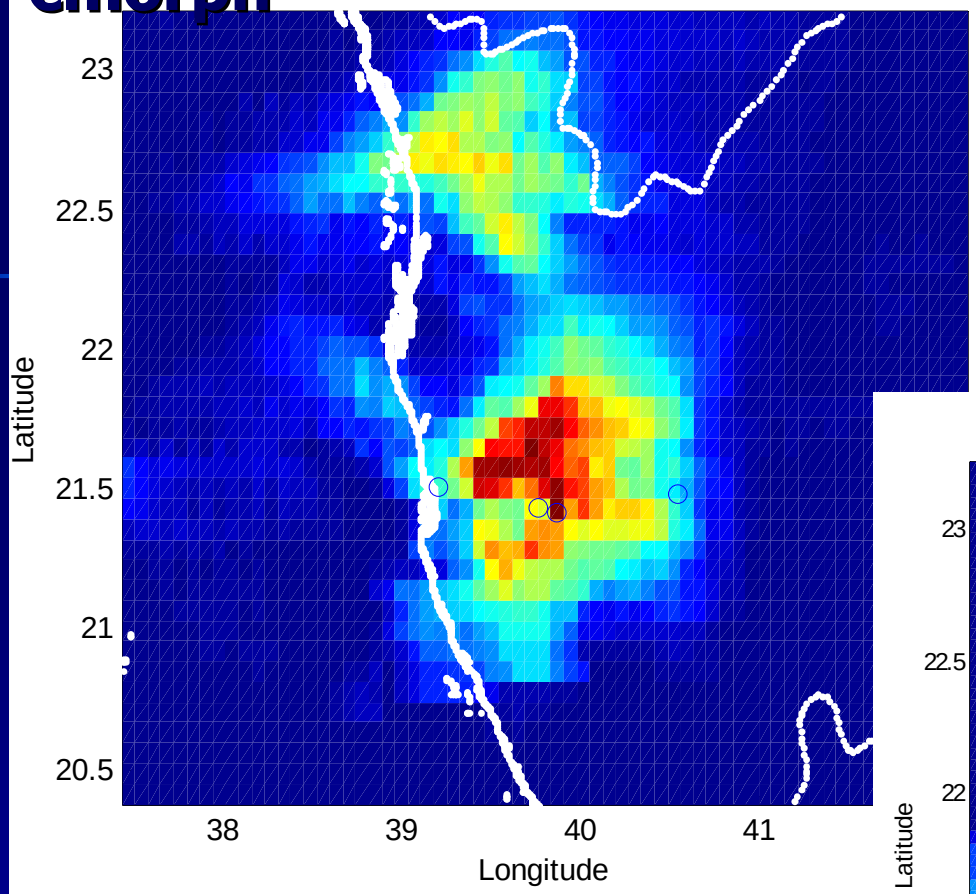

SANAA
TAIZ
AL-BAHA
KHAMIS MUSHAIT/ABHA
Gauge data (mm)
Satellite data (mm)
0
50
100
150
200


Jeddah
Makkah (Mecca)
Port Sudan
Khamis Mushayt
Abha
Jizan
Sanaa
Yemen
Eritrea
Aden

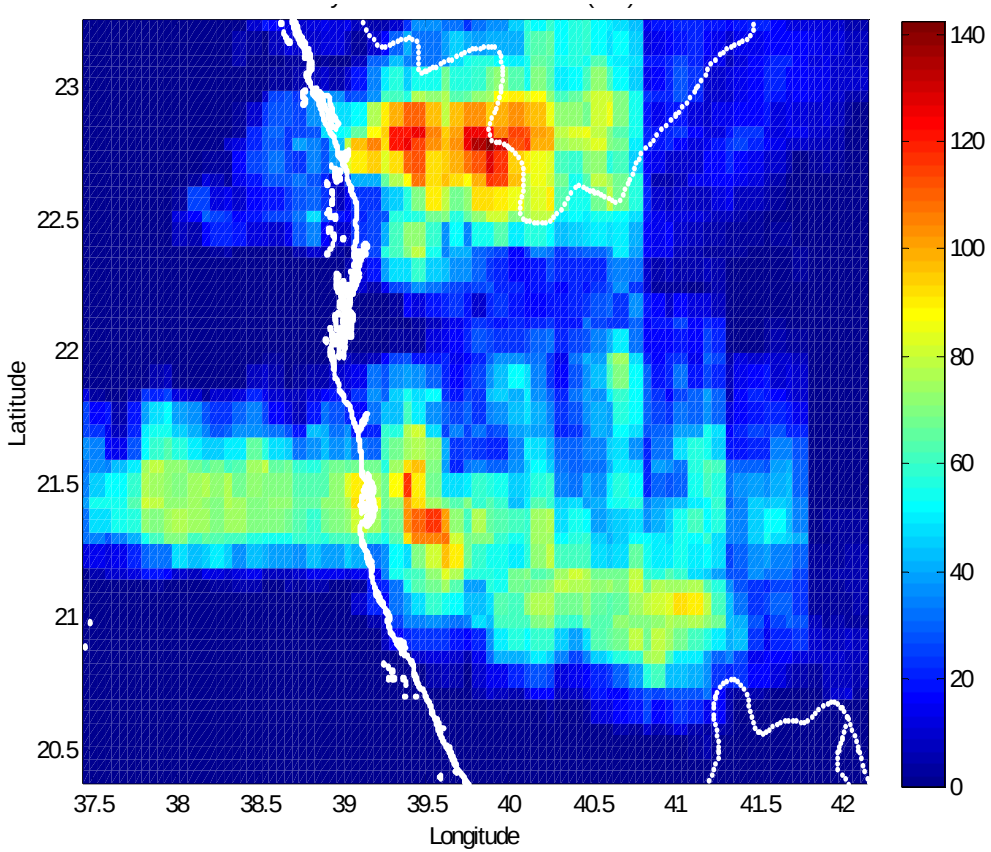
Analysis of very extreme event over western Saudi Arabia

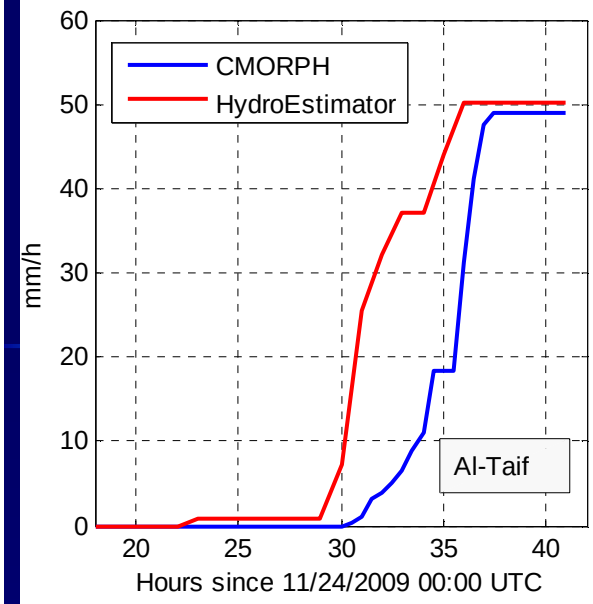

aleqt.com
aleqt.com

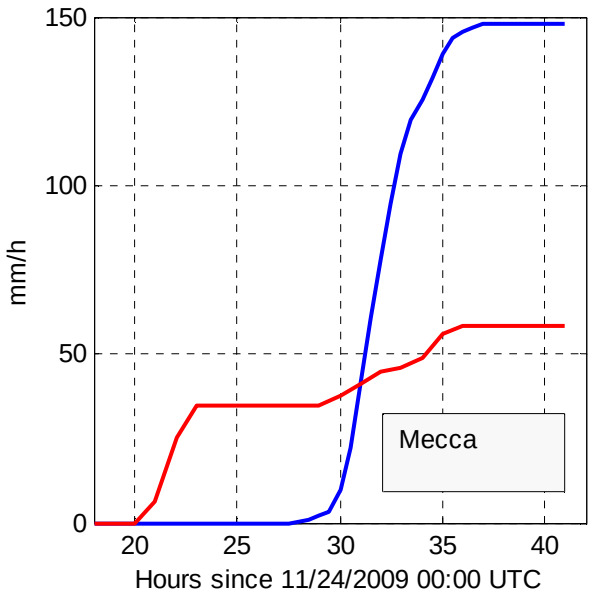
cmorph

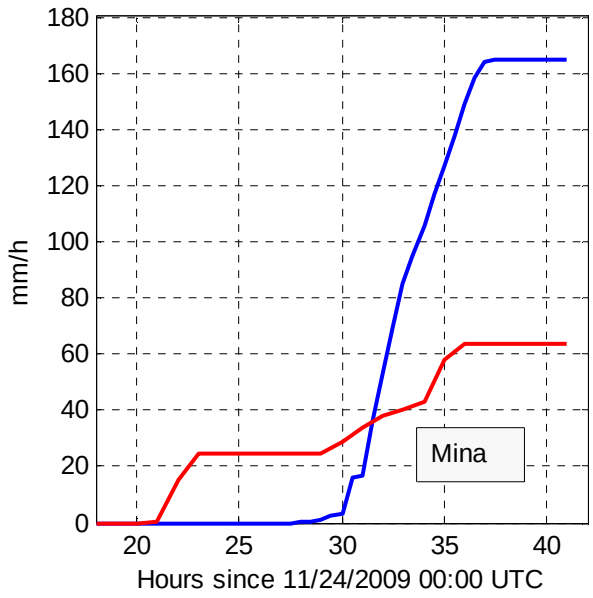


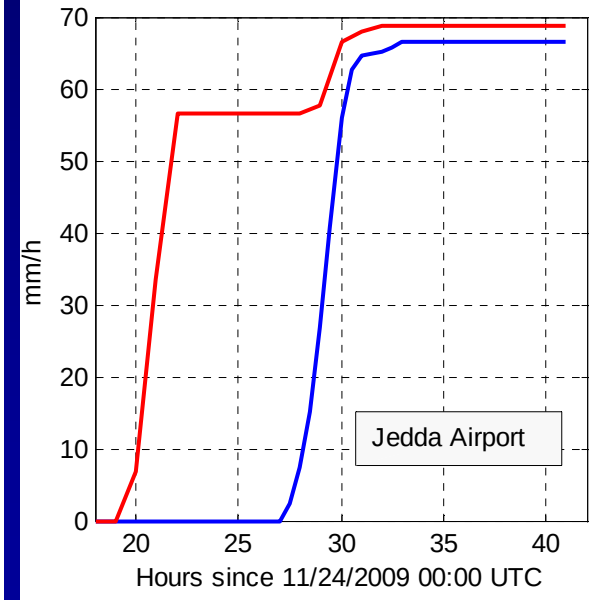
Hydroestimator

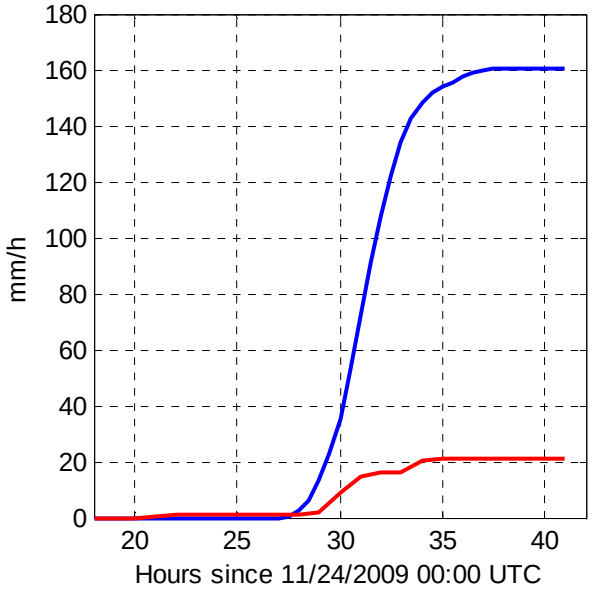


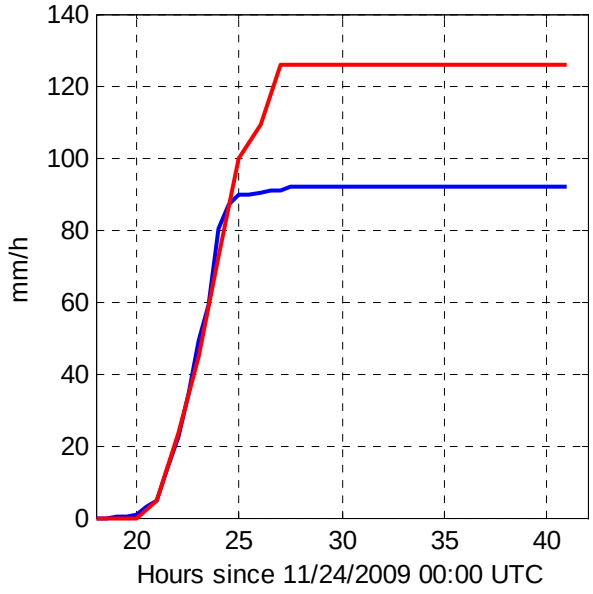

CMORPH
HydroEstimator
Al-Taif
mm/h
Hours since 11/24/2009 00:00 UTC

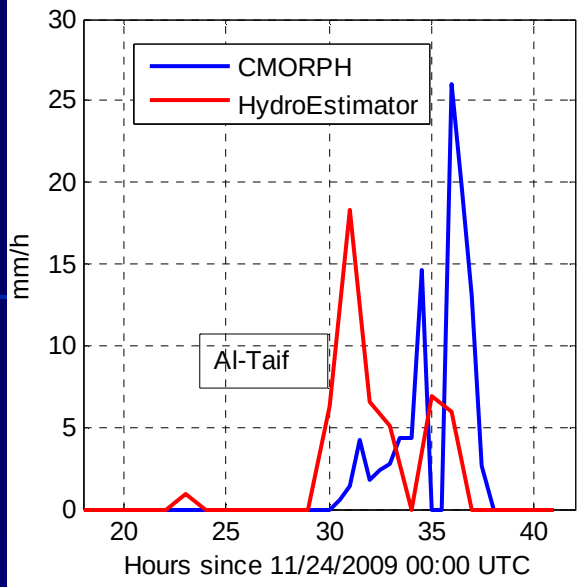

Mecca
mm/h
Hours since 11/24/2009 00:00 UTC

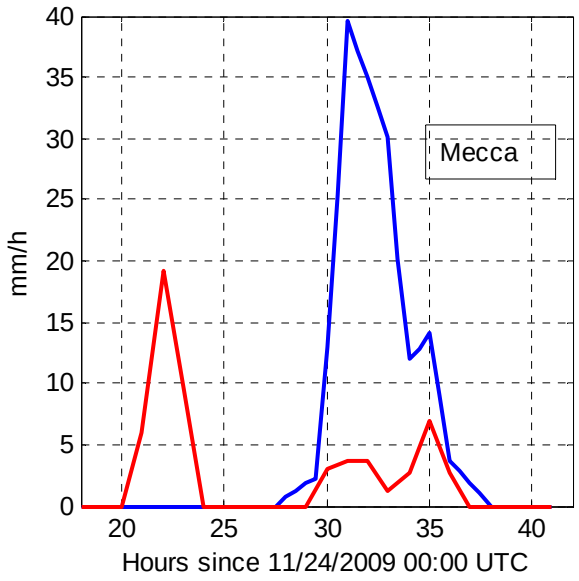

Mina
mm/h
Hours since 11/24/2009 00:00 UTC

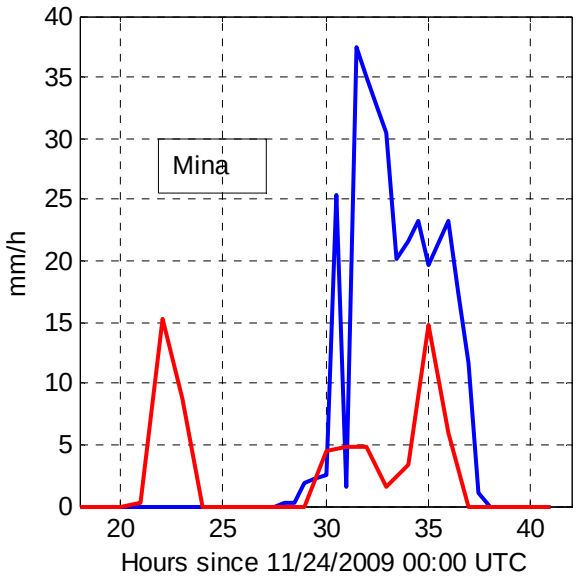

Jedda Airport
mm/h
Hours since 11/24/2009 00:00 UTC

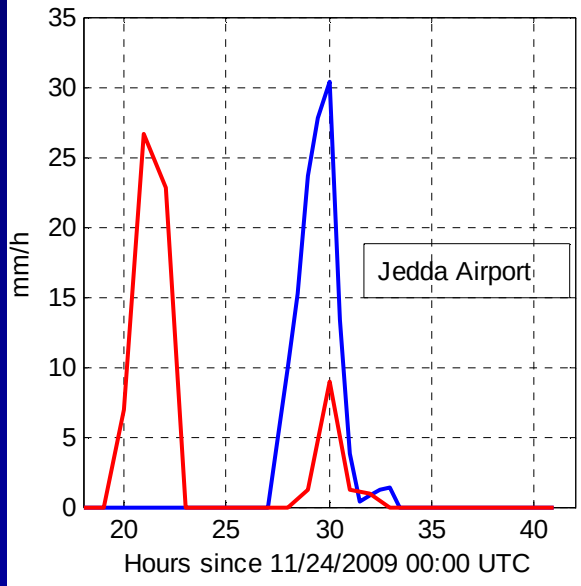

mm/h
Hours since 11/24/2009 00:00 UTC

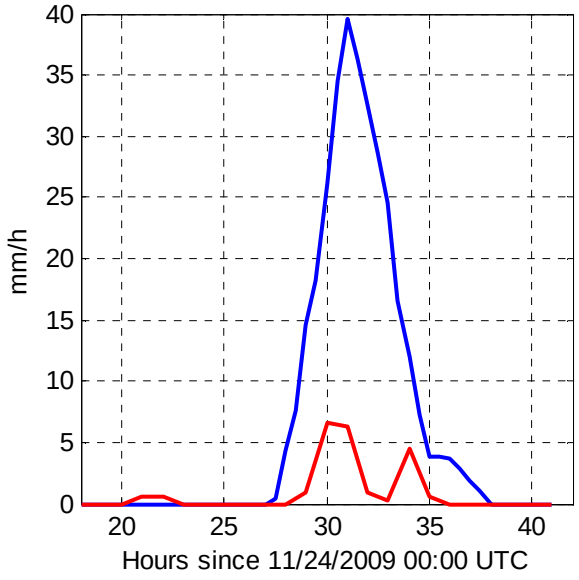

mm/h
Hours since 11/24/2009 00:00 UTC

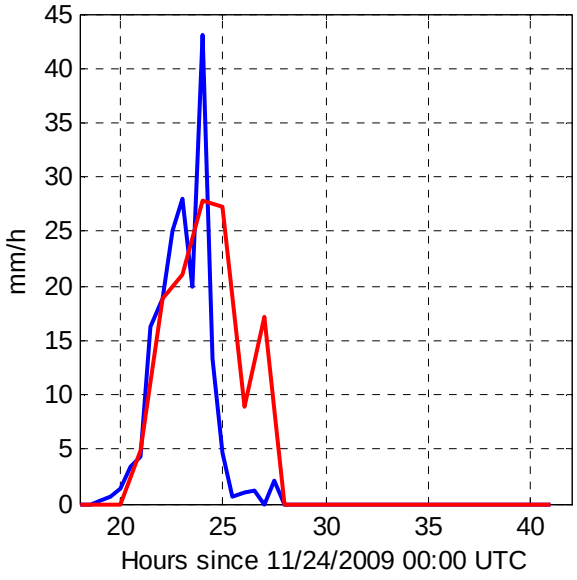

CMORPH
HydroEstimator
Al-Taif
mm/h
Hours since 11/24/2009 00:00 UTC

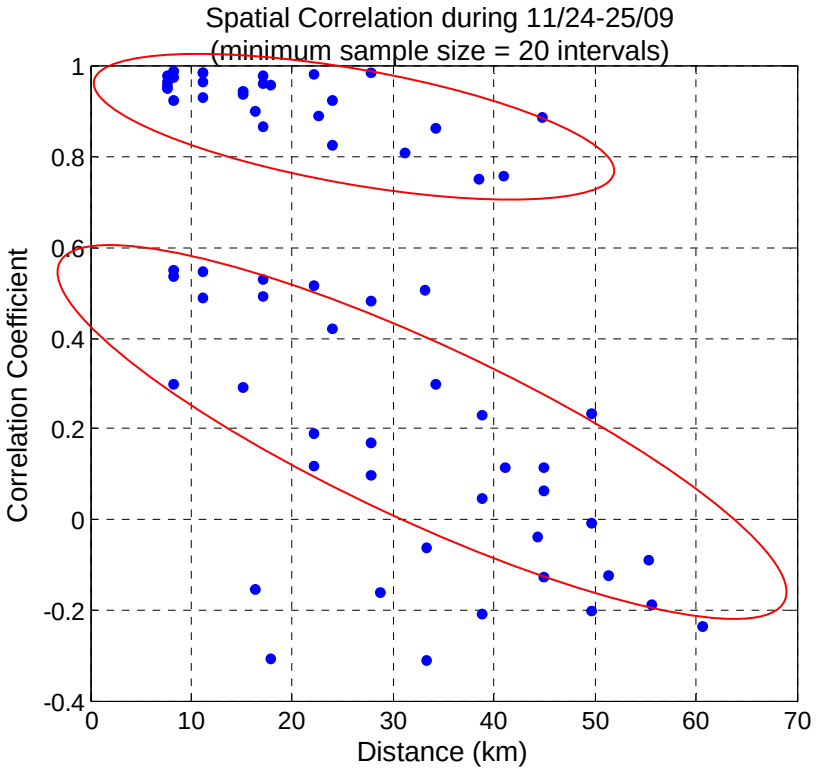

Mecca
mm/h
Hours since 11/24/2009 00:00 UTC


Mina
mm/h
Hours since 11/24/2009 00:00 UTC

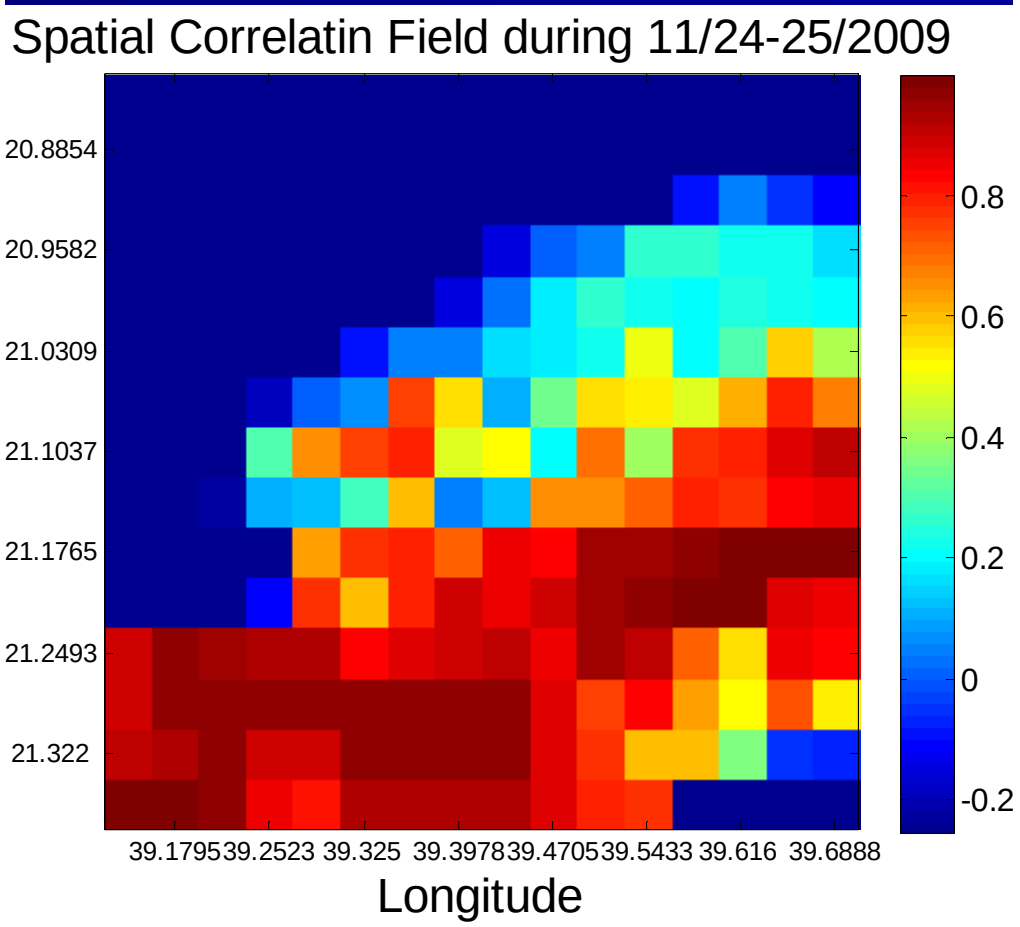

Jedda Airport
mm/h
Hours since 11/24/2009 00:00 UTC


mm/h
Hours since 11/24/2009 00:00 UTC


mm/h
Hours since 11/24/2009 00:00 UTC



Spatial correlation



Concluding Remarks

- The TMPA product successfully reproduces long-term climatology over the selected arid areas
- Some strong-rainfall artifacts are observed in monthly and annual spatial accumulations with both TMPA and CMORPH
  - appears more during cold months and cold hours of the day
  - probably related to desert sand scattering effects
- Satellite products provide remarkable high-resolution representation of a catastrophic event
  - invaluable for flood warning and hydrologic analysis in arid regions
- Apparent differences between different products
  - bring challenges to data users in terms of significance of such differences (magnitude, timing, spatial extent) and their hydrologic implications

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- Dr. Tian Yudong for sharing the CMORPH high-resolution dataset