EXTREME WEATHER EVENTS IN THE SNEEUBERG MOUNTAINS, KAROO, SOUTH AFRICA

A CASE STUDY OF THE FLOODS OF FEBRUARY 9TH & 12TH, 2011

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29.04.2013

8.05.2013

Presentation available at: http://roddyfox.wordpress.com/

2012 MyCOE / SERVIR Initiative in East Africa

THE UNIVERSITY OF NORTHAMPTON

- INTRODUCTION TO THE STUDY AREA
- MOTIVATION
- ANALYSIS OF THE EXTREME EVENTS:
  - Longer term times series 1986-2011- comparison with Global Precipitation Climate Centre (GPCC) and Global Precipitation Climatology Project (GPCP) data;
  - Shorter-term time series, daily and hourly record for 9-12 February - comparison with Modern Era Retrospective Analysis for Research and Applications (MERRA) data;
  - Spatial distribution of precipitation on 9 February - comparison with Global Land Data Assimilation System (GLDAS) and TRMM data.
- CONCLUSIONS

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THE STUDY AREA

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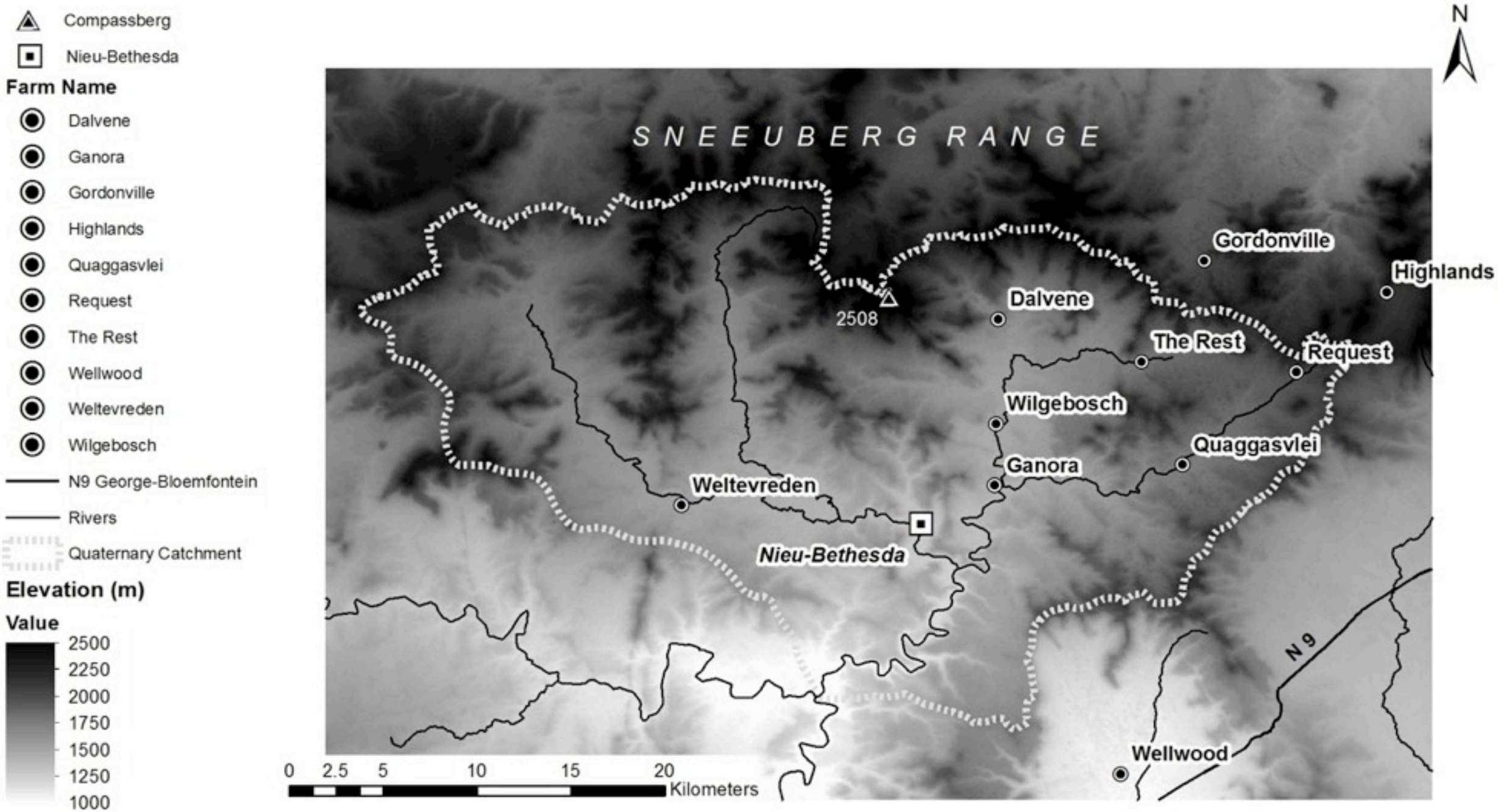
CATCHMENT AREA



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FURROW SYSTEMS

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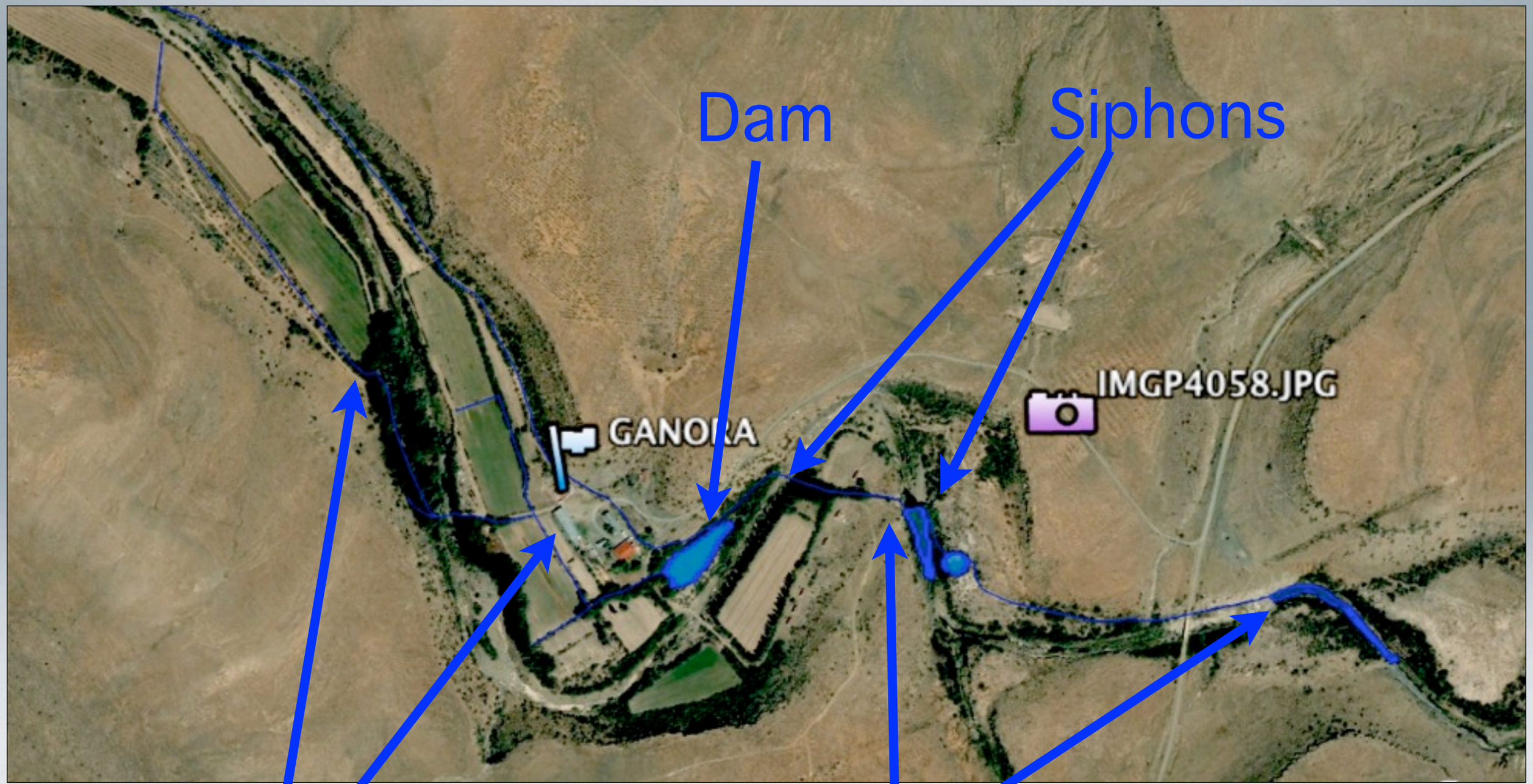

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SUMMER STORMS

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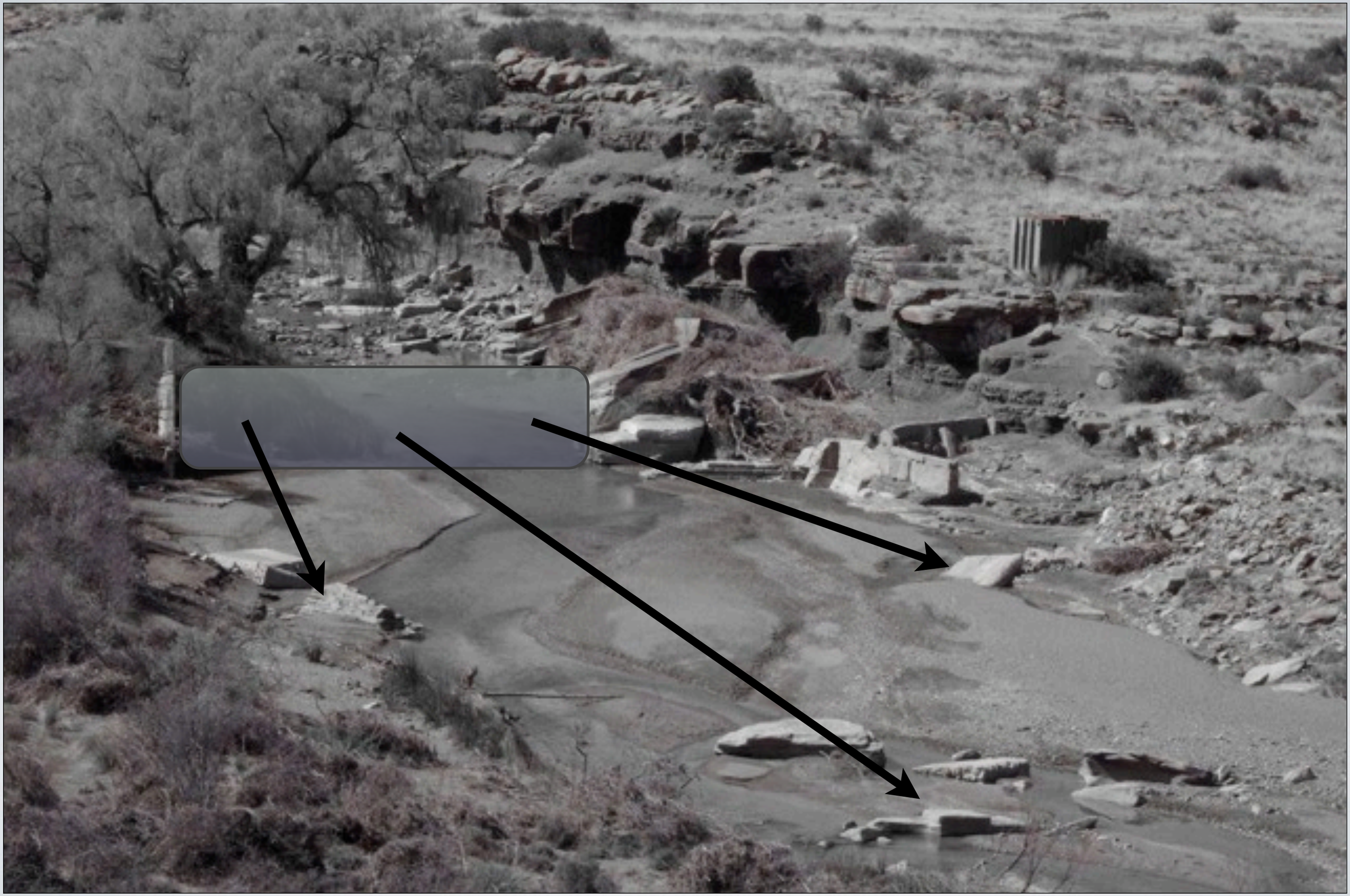

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PREVIOUS DESTRUCTIVE EVENTS IN 1961 AND 1974

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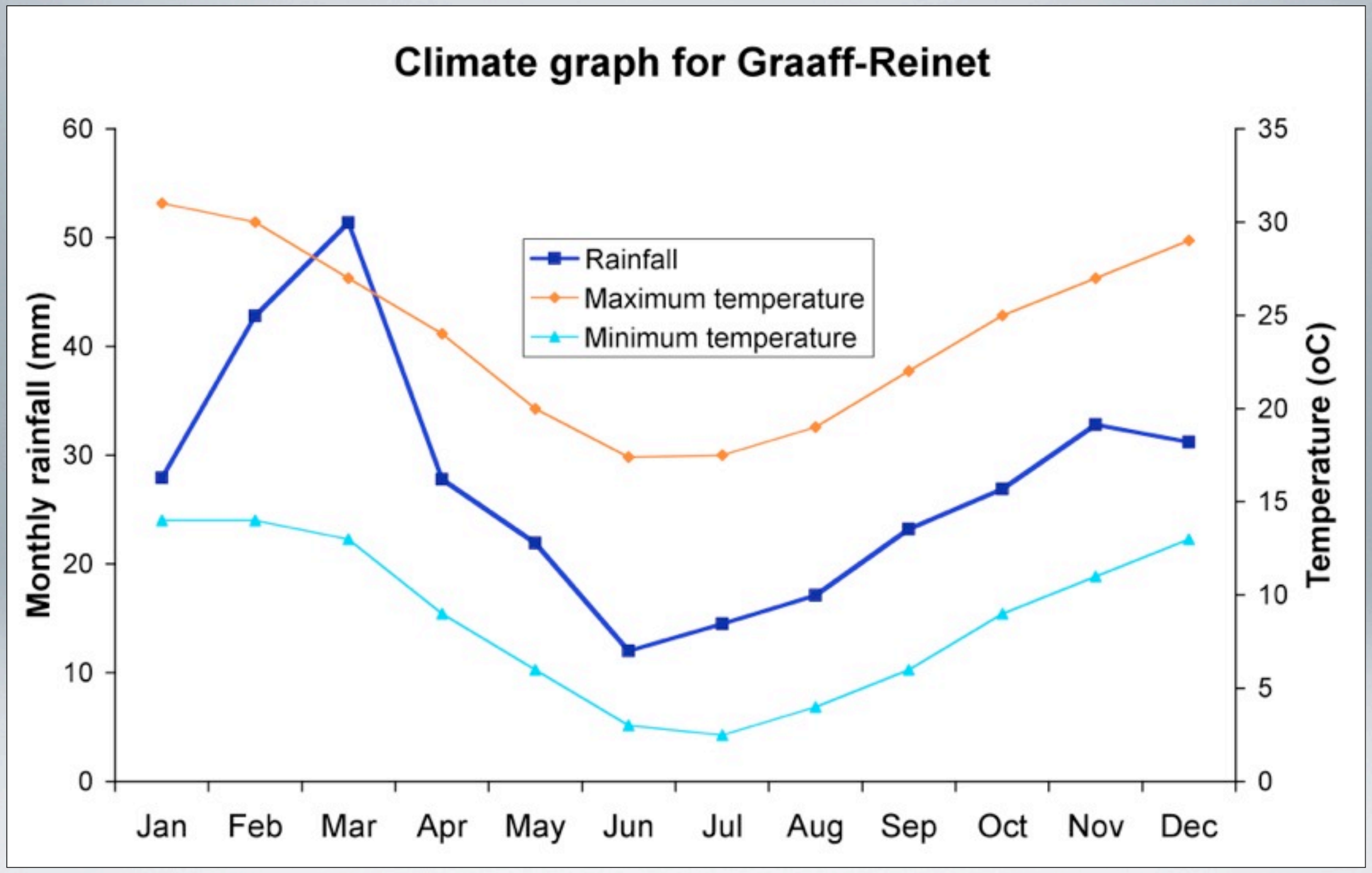

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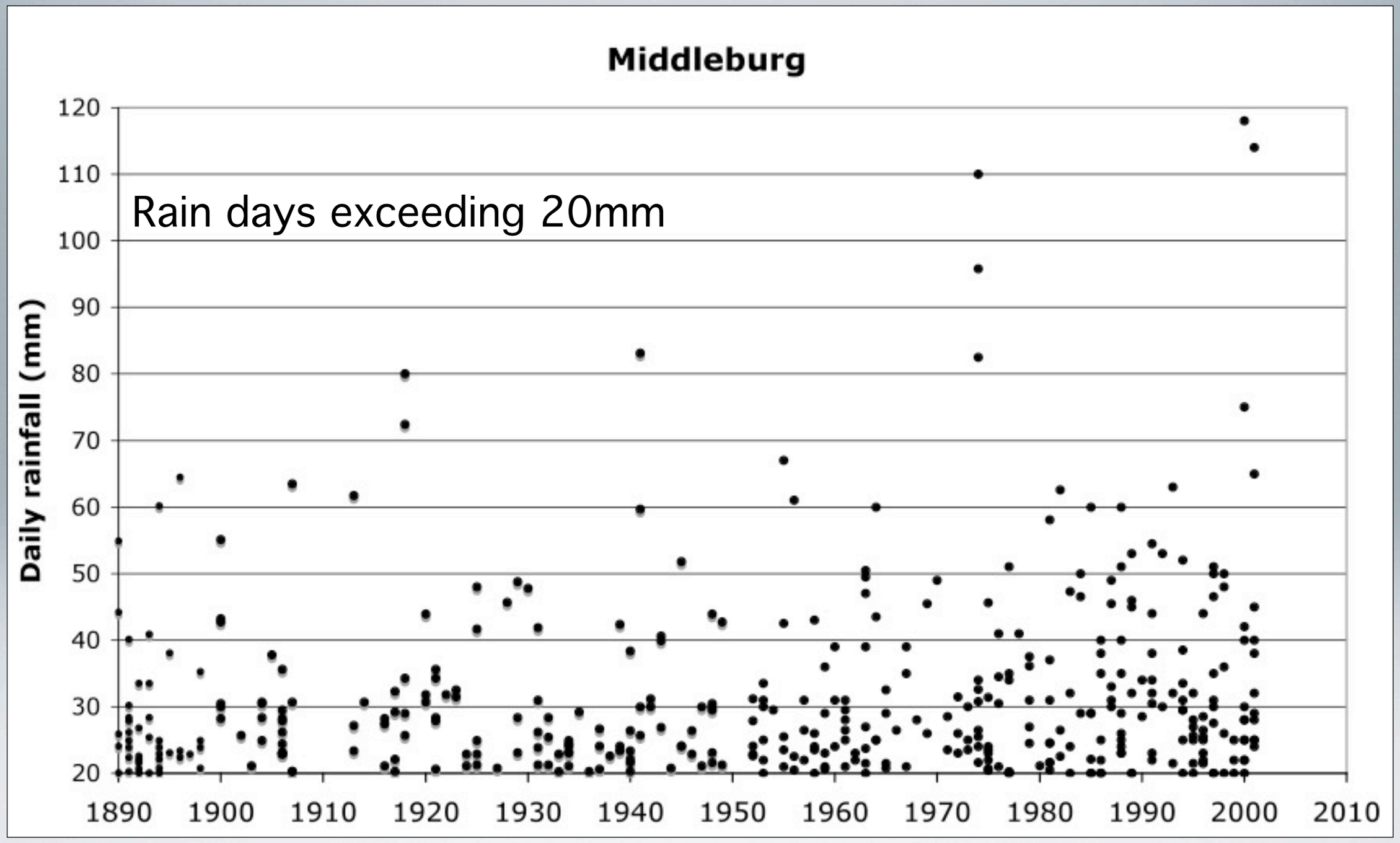

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MOTIVATION

- Classic mountain area:
  - In South Africa altitude >850m, slope >5^0, elevation range >300m;
- Collected a high density of rainfall records for a semi-arid mountainous catchment including:
  - one of the country's oldest rainfall stations (Wellwood);
  - autographic rain gauge;
- Possible to compare modelled data (accessed via the Giovanni data portal) with the actual flood events of February 2011;
- For a remote, marginal area there is an unusually large amount of scientific and socio-economic study:
  - Land degradation, land management, biodiversity, paleontology;
  - Unique sense of place, culture, economic importance.

Installing the autographic rain gauge 25 January 2009

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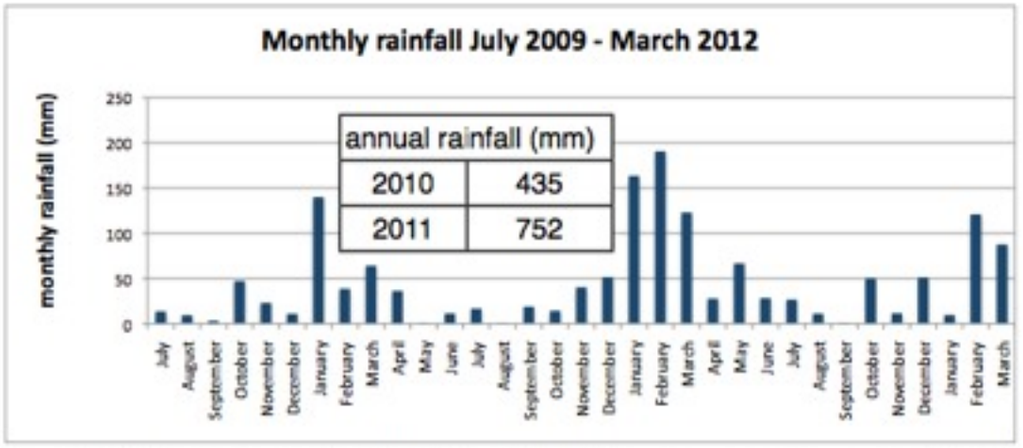
An autographic raingauge was installed at Ganora in 2009; the first readings were recorded in July of that year. Rainfall enters the bucket which tips once 0.2 mm is received. Each tip sends a signal to the recording device which records the total number of tips over a 5 minute interval.



Monthly rainfall figures demonstrate that the 2010-2011 summ
with the rains starting in September, reaching a peak in Janua
through June and July. The 2009-2010 and 2011-2012 summe
erratic. The high annual total for 2011 can be seen from the insert

days >= (mm)	Oct	Nov	Dec	Jan	Feb	Mar	April
70.0					1		
40.0	2			2	1		
30.0			1	2	1		
20.0		1		1	1	6	1
10.0			2	2	9	2	1
5.0	2	4	4	2	5	8	1
2.0	2	7	7	11	4	10	2
0.2	15	12	11	26	19	15	26
no. of days in record	93	90	93	93	85	93	60
no. rain days	21	24	25	46	41	41	31
% days with rain	23	27	27	49	48	44	52

1											
2											
1											
1											
3			1			1					
1	3		2								
1	1	3	2	7	5	2					
26	12	19	22	13	6						
60	62	60	93	93	90						
31	21	24	32	18	9						
52	34	40	34	19	10						

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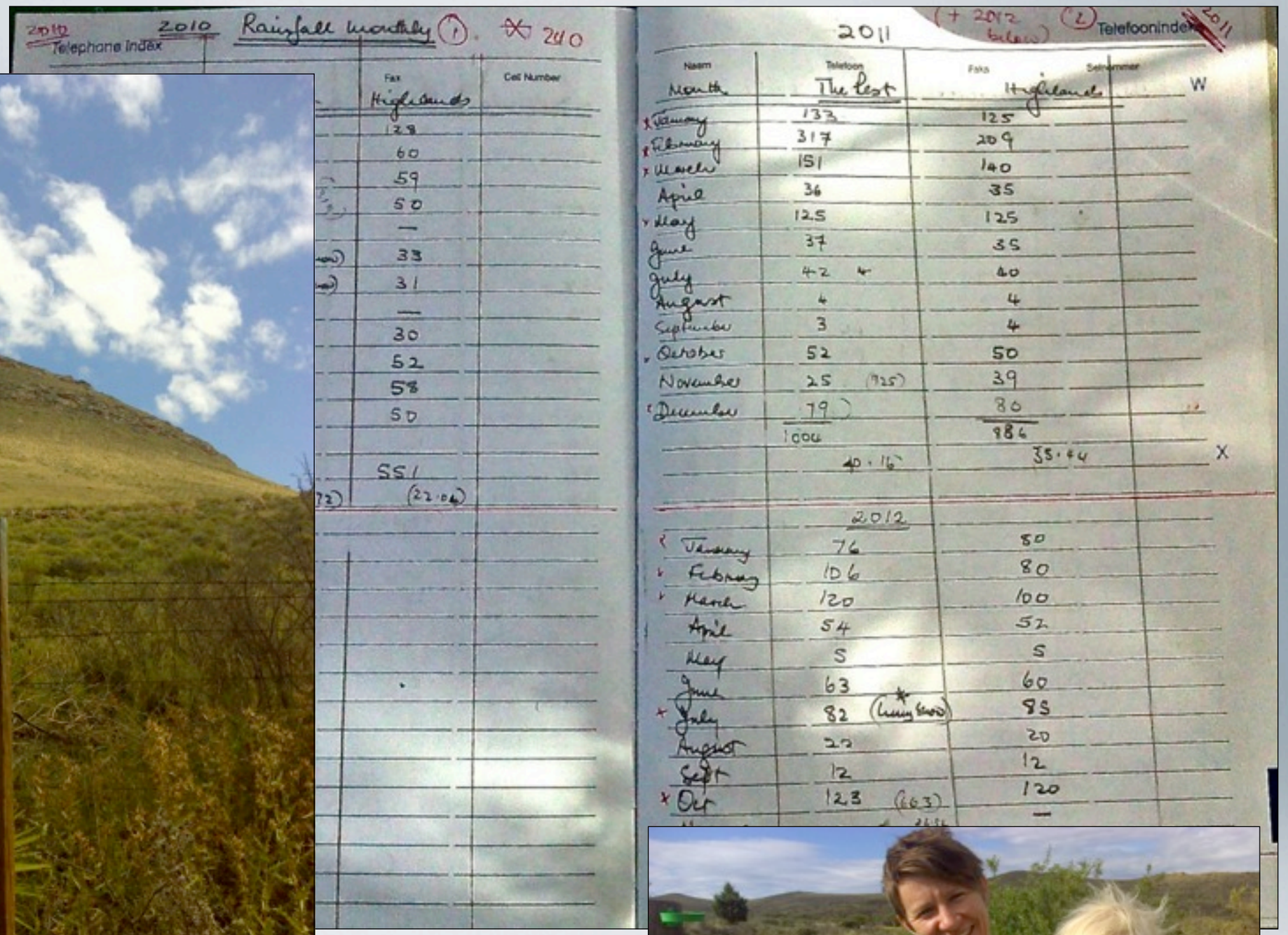

Collecting the farm record

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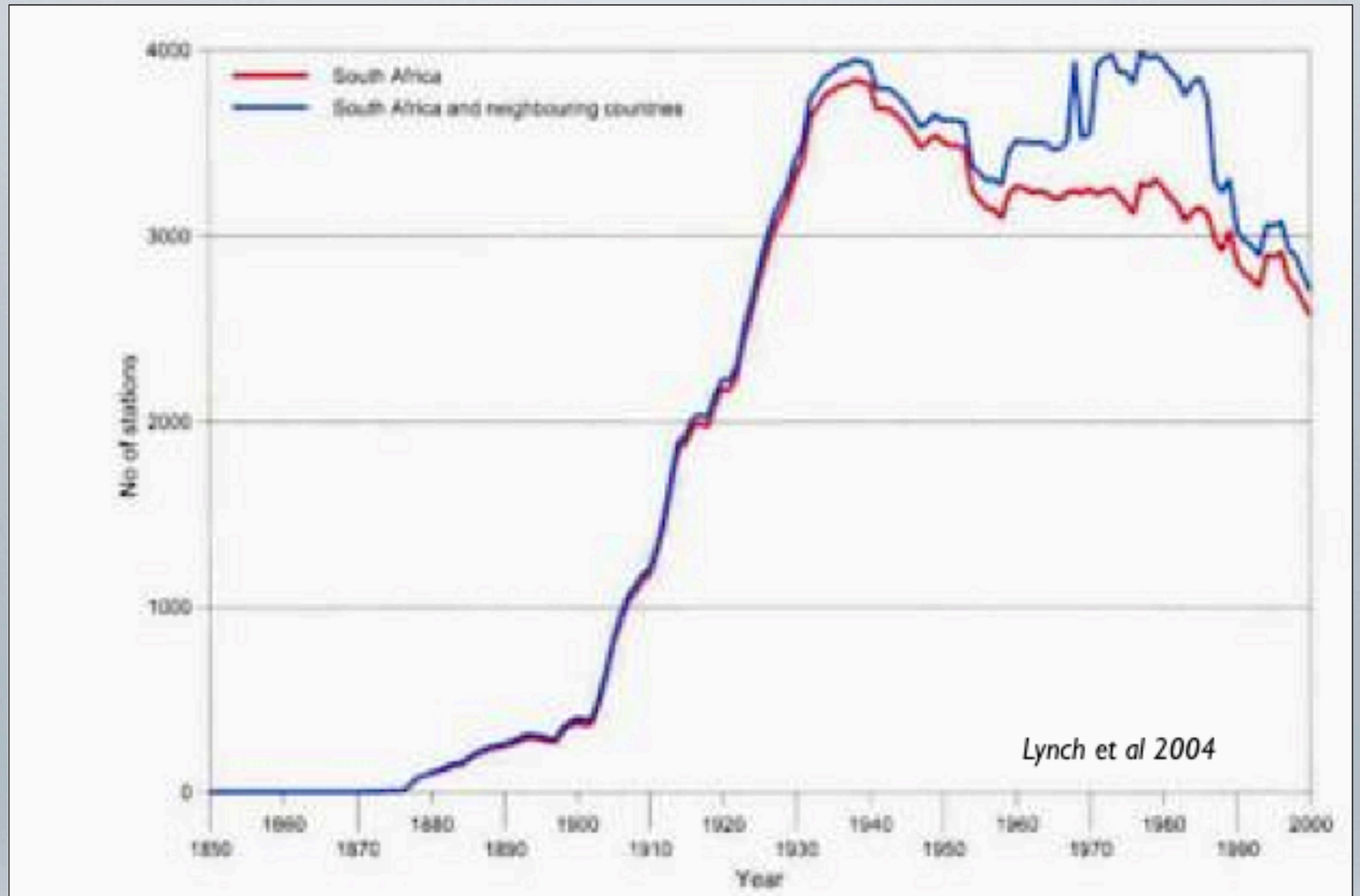
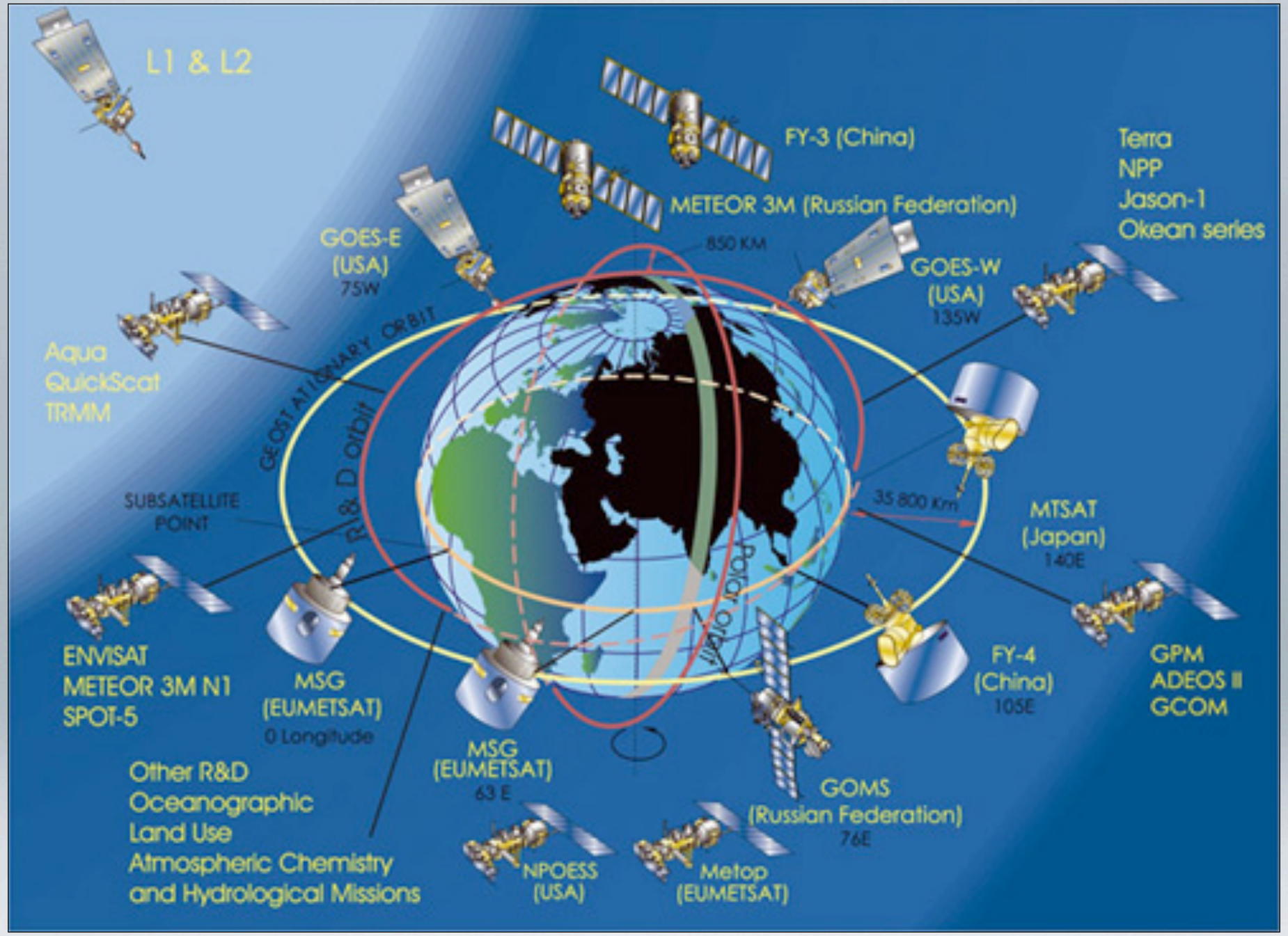


Figure ES3 Number of active rainfall stations over time in southern Africa

DECLINE IN THE NUMBER OF STATIONS SINCE 1940



EARTH OBSERVATION SYSTEMS

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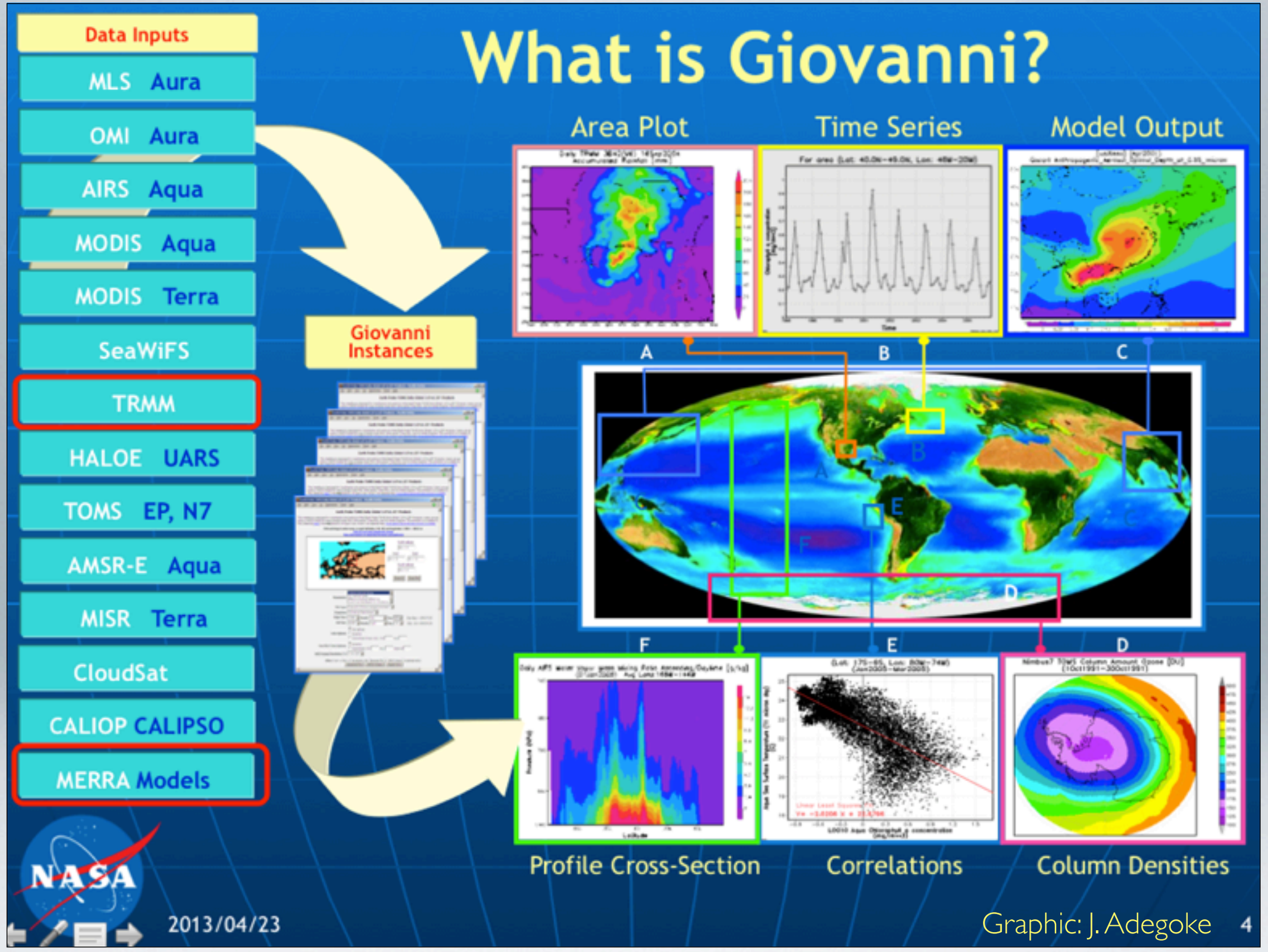

ACCESS, ANALYSIS AND PRESENTATION OF EOS DATA FACILITATED BY GIOVANNI

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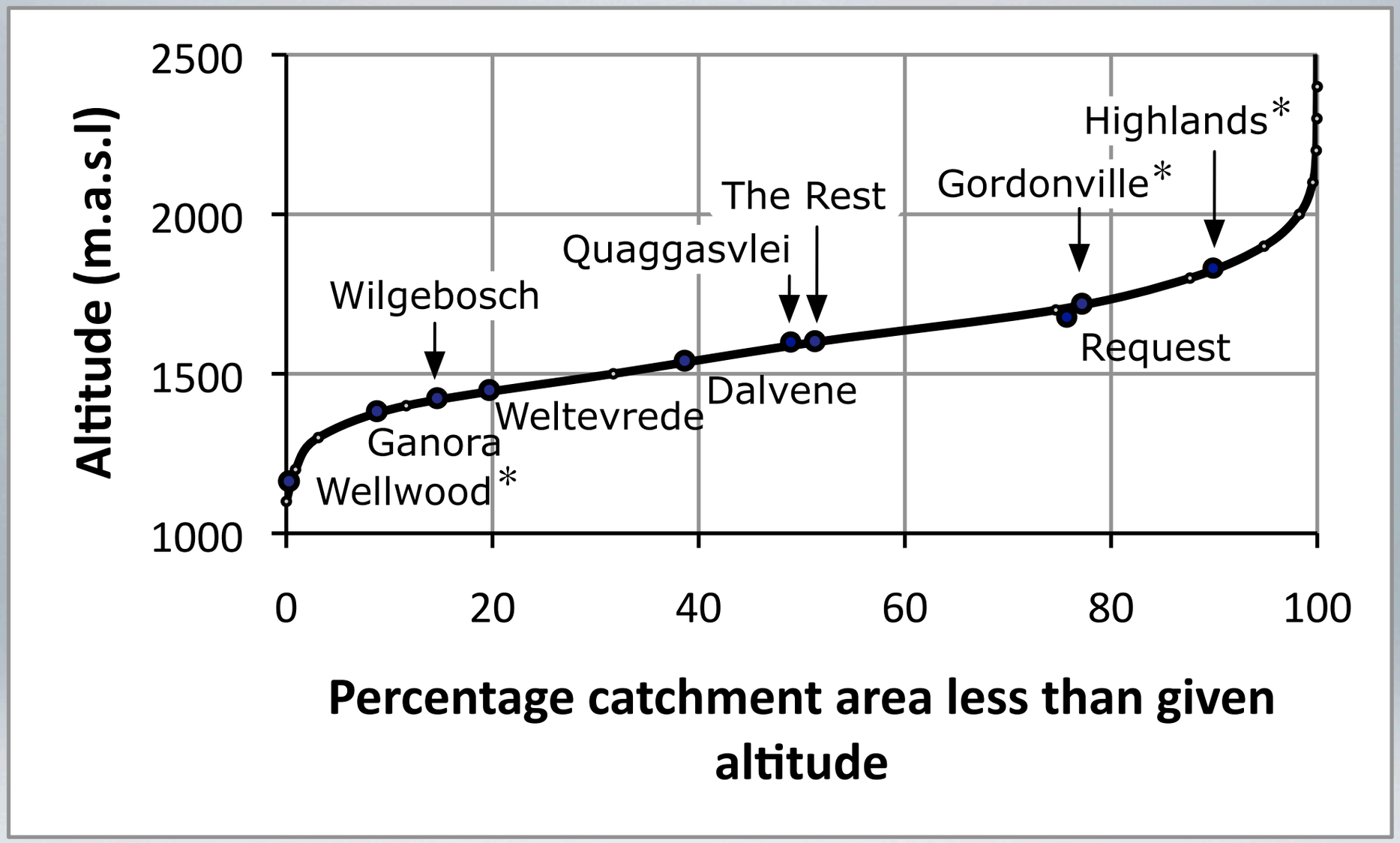
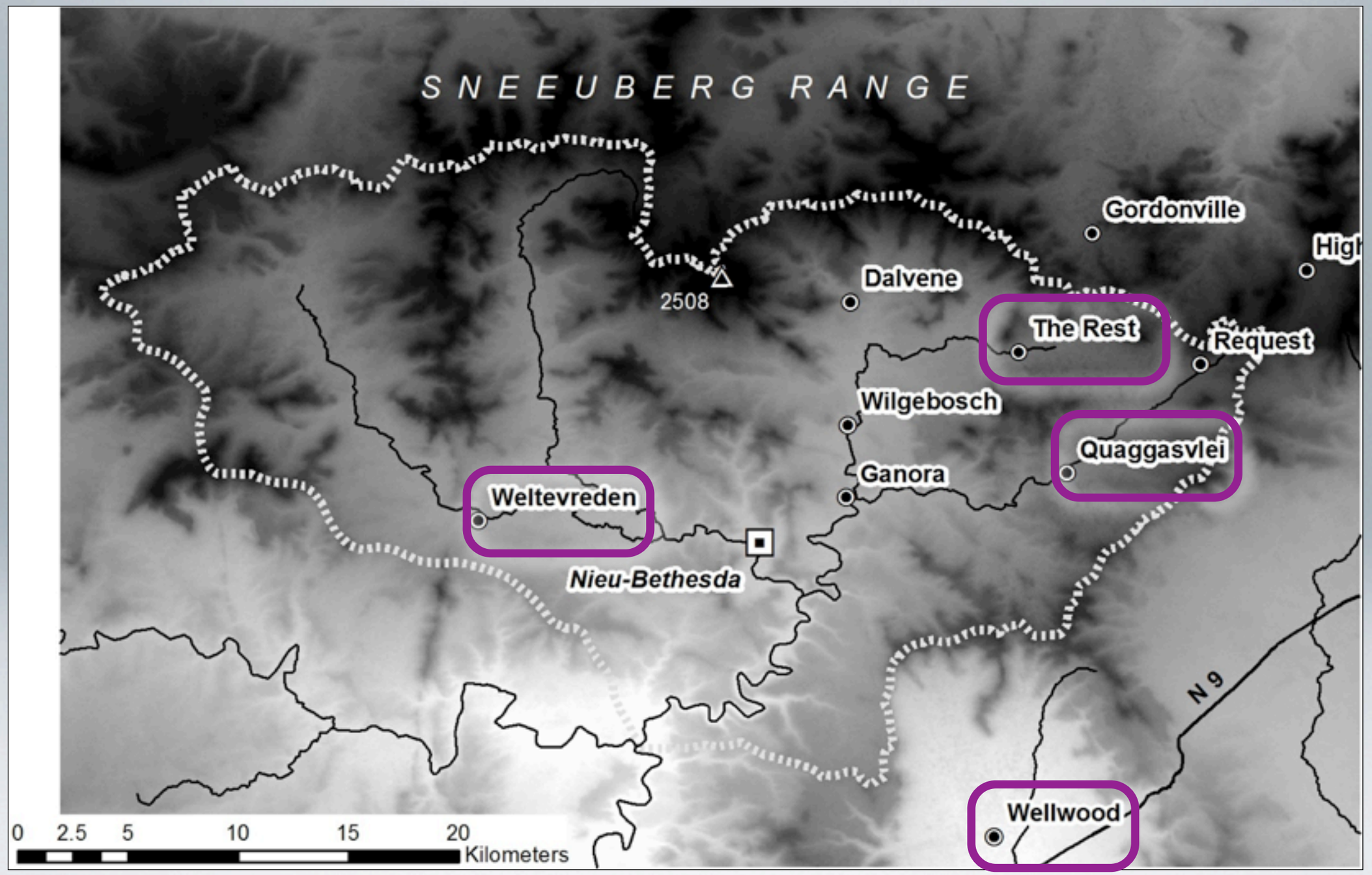
ANALYSIS



- Rainfall stations have a good altitudinal range
- Grouped towards the eastern side of the catchment

LONGER TERM TIME SERIES: ANNUAL



- Wellwood (data since 1874), Weltevreden (1950), Quaggasvlei (1950) The Rest (1969)

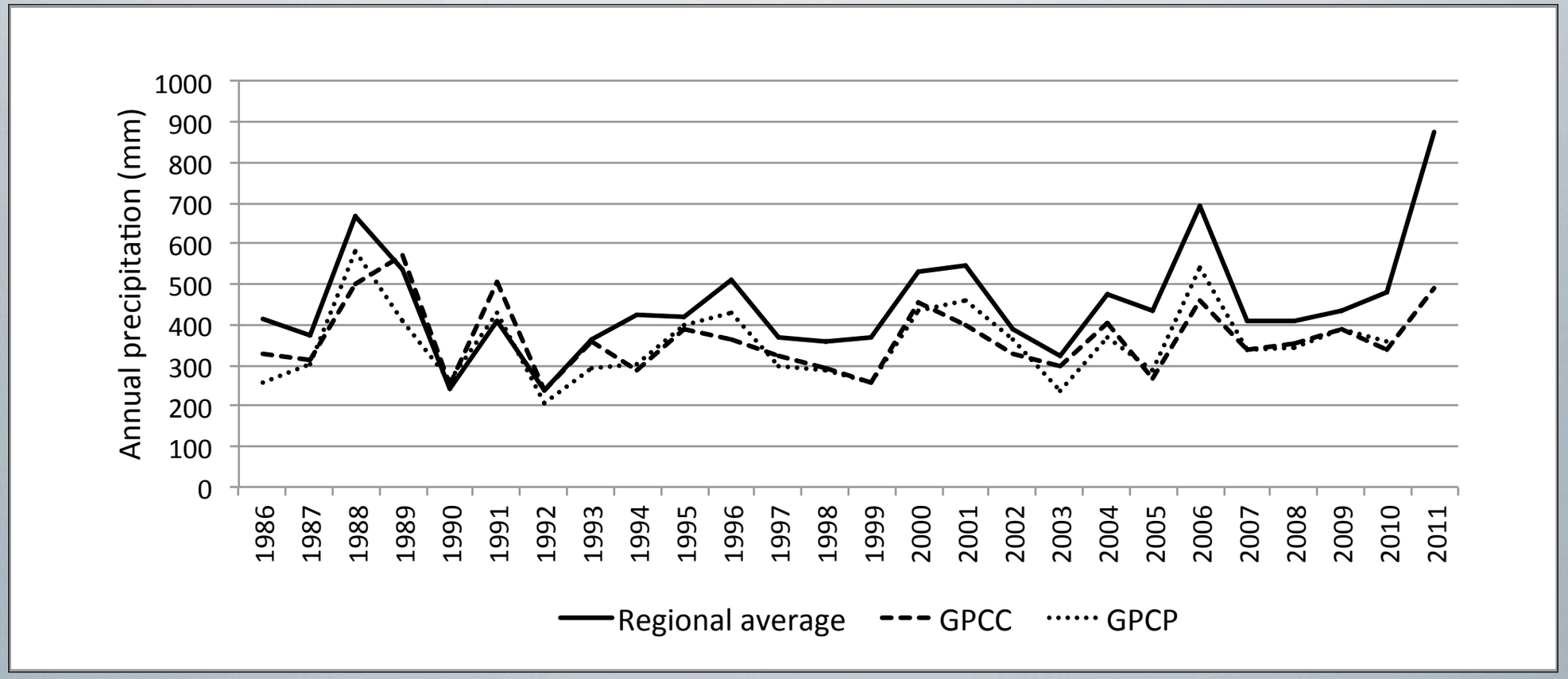
- Reliability examined through correlation and regression of cumulative rainfall of pairs of stations with Wellwood

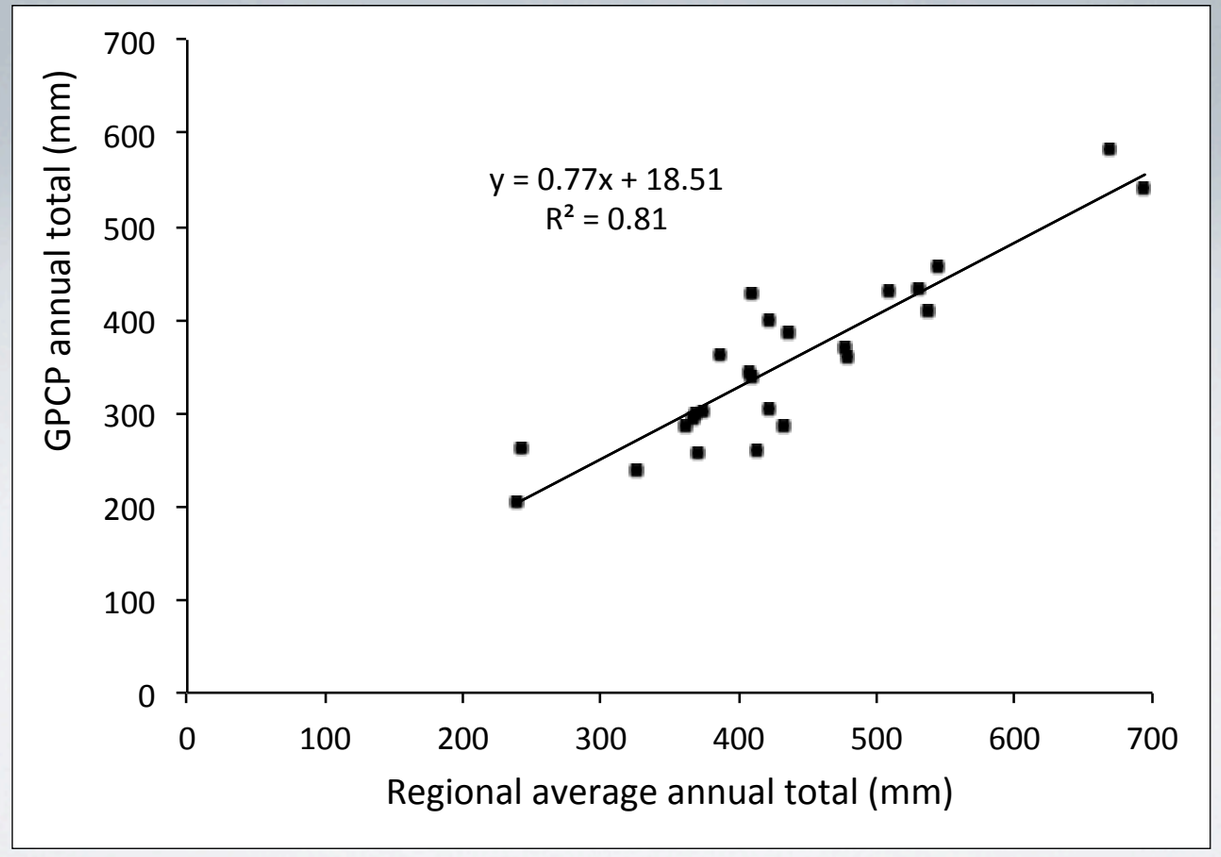
- Wellwood and Weltevreden $y = 1.0171x - 393.11$ $R^2=0.9978$
- Wellwood and Quaggasvlei $y = 1.1156x - 367.46$ $R^2=0.99925$
- Wellwood and The Rest $y = 1.4471x - 10250$ $R^2=0.99436$
- Quaggasvlei and The Rest $y = 1.2766x - 9420.8$ $R^2=0.99611$

- Annual average (for the four stations) 450 mm, Standard Deviation 136 mm (1986-2011)

- GPCC_RAIN.004 Area average 366 mm, Standard Deviation 88 mm (1986-2011). Underestimates the average and the variance: good relationship with actual patterns of wet and dry years.

- Best relationship, however, is between monthly GPCP data and regional average: $R^2 = 0.81$. Average 353 mm, Standard Deviation 93 mm.





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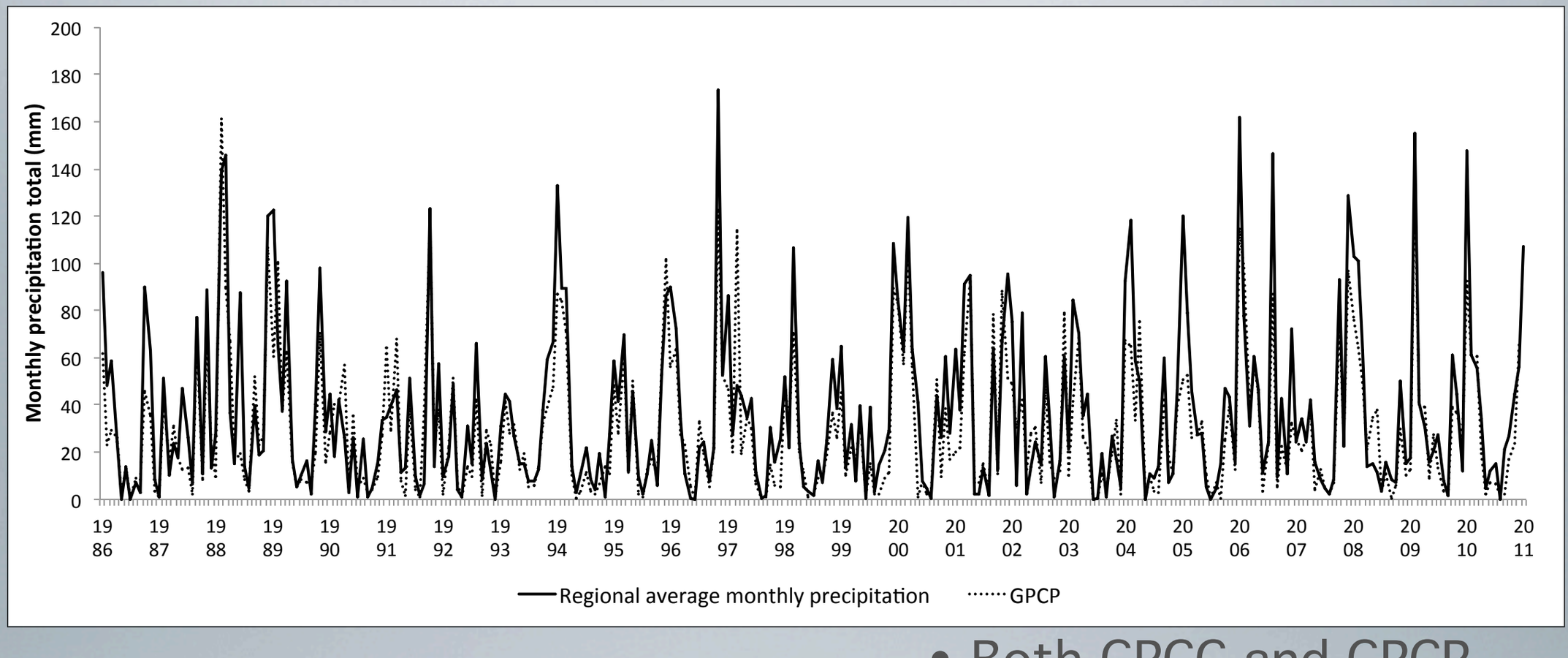
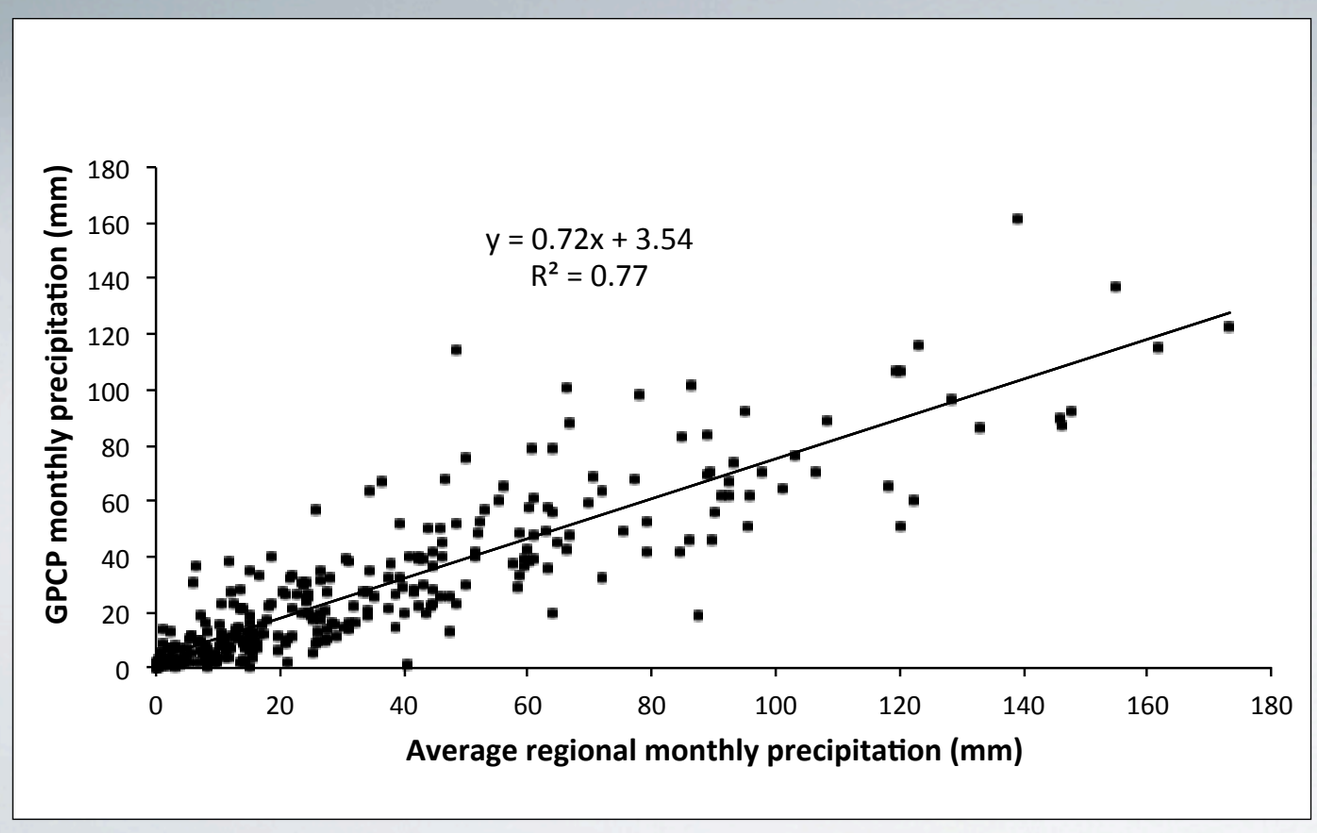
LONGER TERM TIME SERIES: MONTHLY





- Both GPCC and GPCP monthly data also underestimates the average and the variance.
- Good R^2 value, indicating a strong relationship between the regional average and modelled data.

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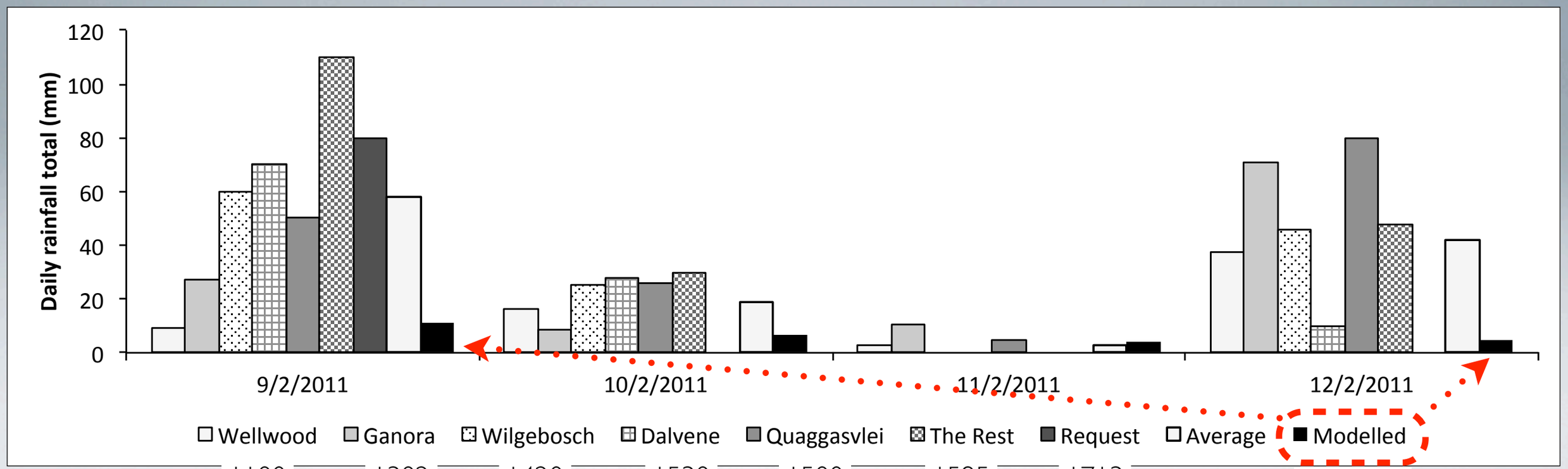
SHORT TERM TIME SERIES: DAILY 9TH TO 12TH FEBRUARY

- Seven stations with reliable data: Wellwood (1180m), Ganora (1382m), Wilgebosch 1420m), Dalvene (1538m), Quaggasvlei (1580m), The Rest (1595m) and Request (1713m).

- Precipitation strongly correlated with altitude on 9th February: R^2 0.78



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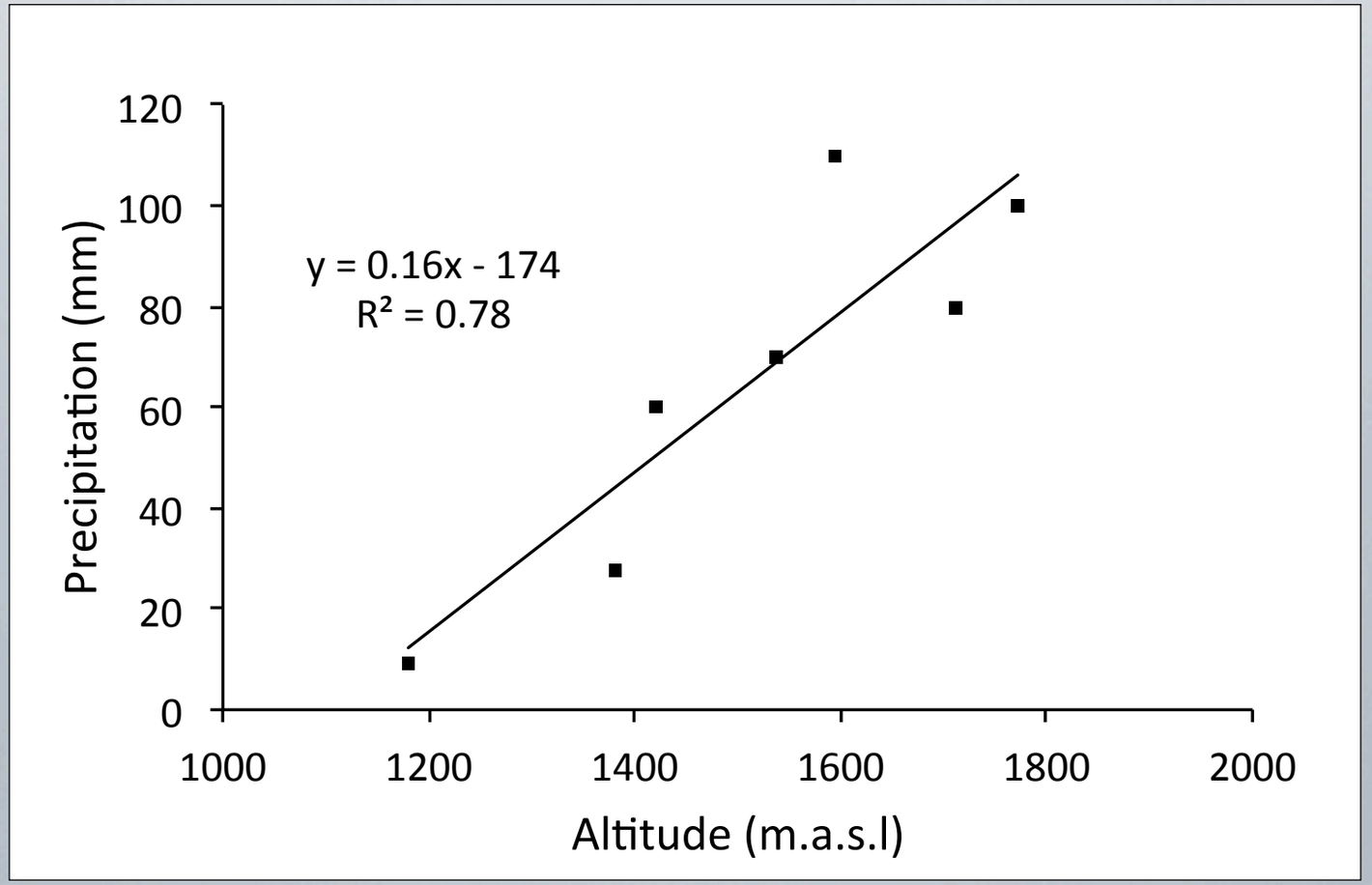

- Altitude has a much weaker affect on the 12th

- MERRA hourly history data (MAT1NXFLX.5.2.0) for the area is a poor estimate

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SHORT TERM TIME SERIES: HOURLY 9TH TO 12TH FEBRUARY

- Ganora Farm's autographic rain gauge (1382m) record was sharply peaked at 21.6mm/hr at 16.00 on 9th and 36.6mm/hr at 15.30 on 12th ie high intensities for a short period.

- Maximum MERRA intensities were 1.5mm/hr at 13.00 on 9th and 1.1mm/hr at 15.00 on the 10th (when the autographic record was similar). The peaks were much more broadly based ie very low intensities of rain were estimated to fall over a longer period.

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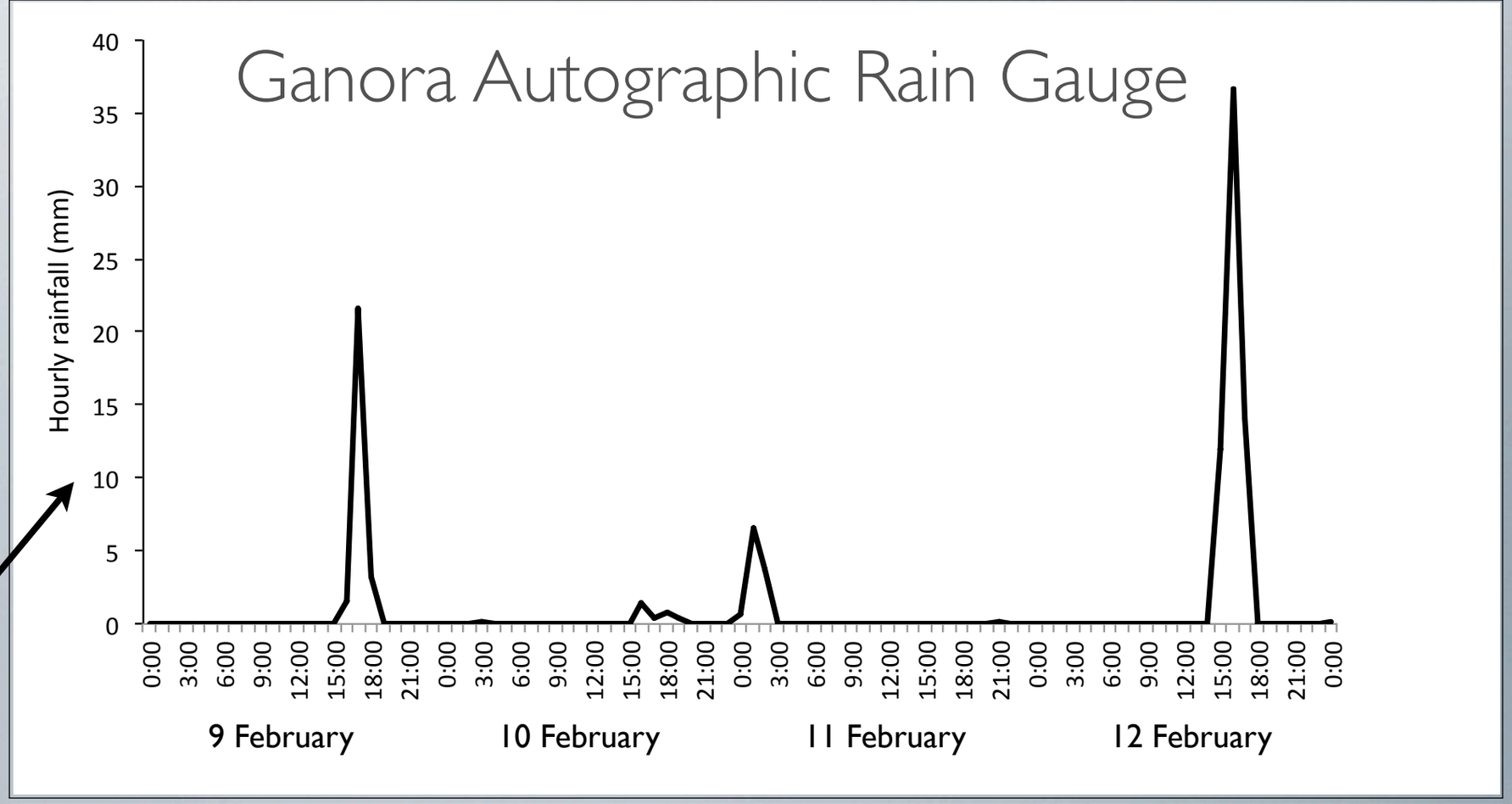
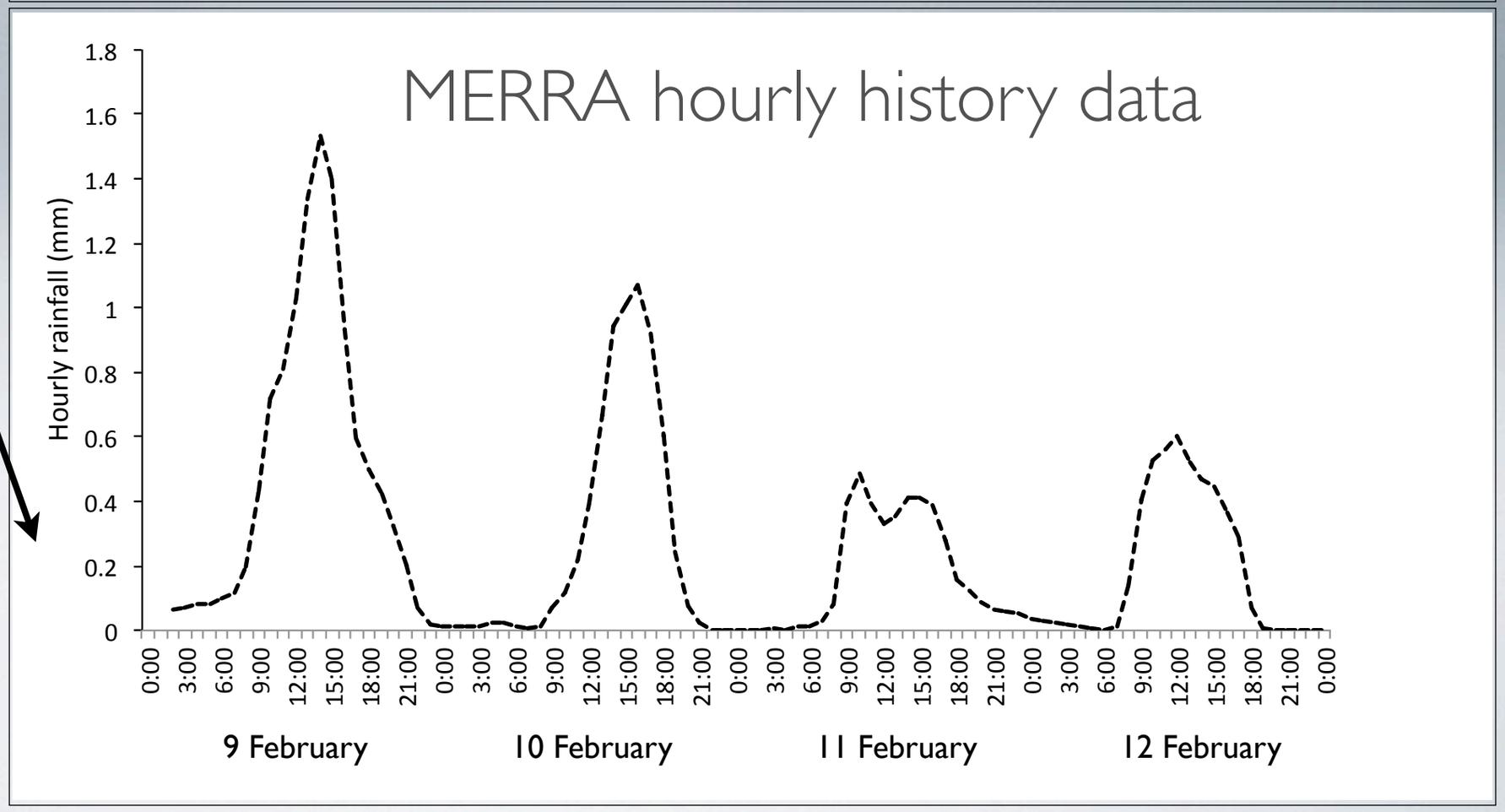
Note the scales





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SPATIAL VARIATIONS

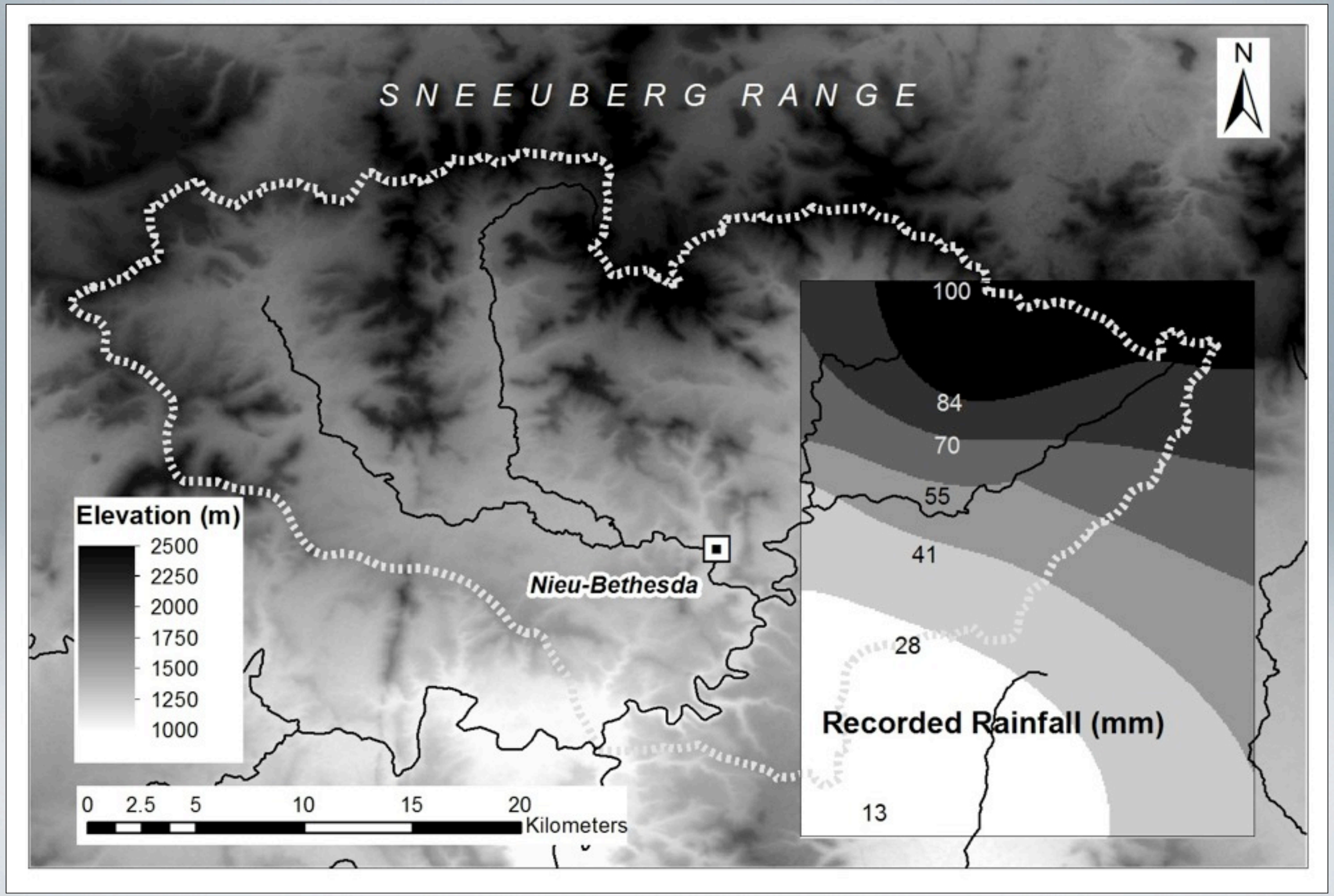
- Rainfall isopleths based on records for February 9th and 12th for Wellwood (1180m), Ganora (1382m), Wilgebosch 1420m), Dalvene (1538m), Quaggasvlei (1580m), The Rest (1595m) and Request (1713m).

- Rainfall isopleths drawn (using the kriging function in ArcGIS) for area specific data products:

  - TRMM_3B42.007 'latlong' plot of accumulated precipitation for February 9th

  - GLDAS_NOAH025SUBP_3H.001 'latlong' plot of accumulated precipitation for February 9th and 12th

9TH FEBRUARY



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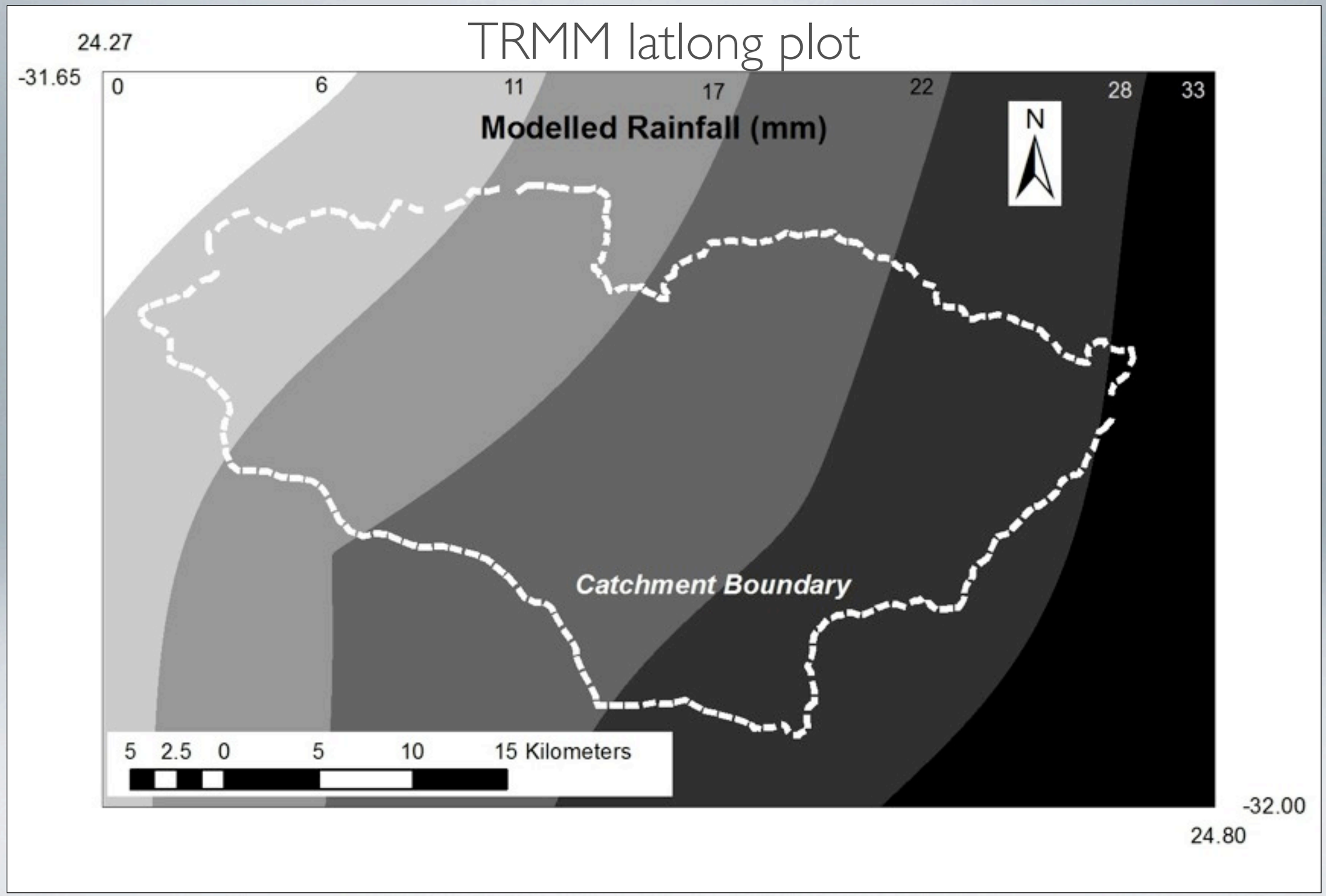
9TH FEBRUARY

TRMM latlong plot



- West to East trend, lower values (0-33mm)

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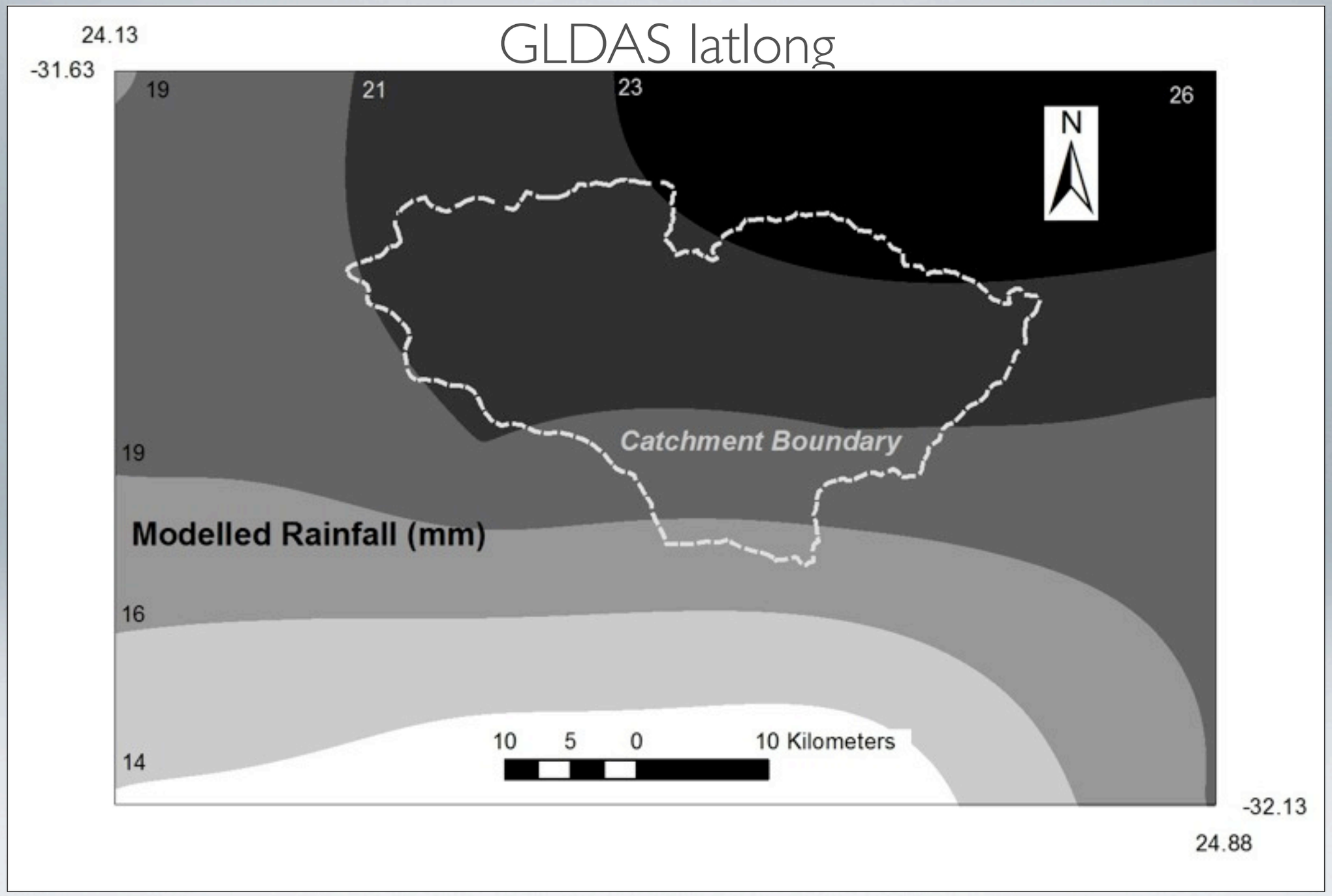
9TH FEBRUARY



- South to North trend, lower range of values (14-26 mm)

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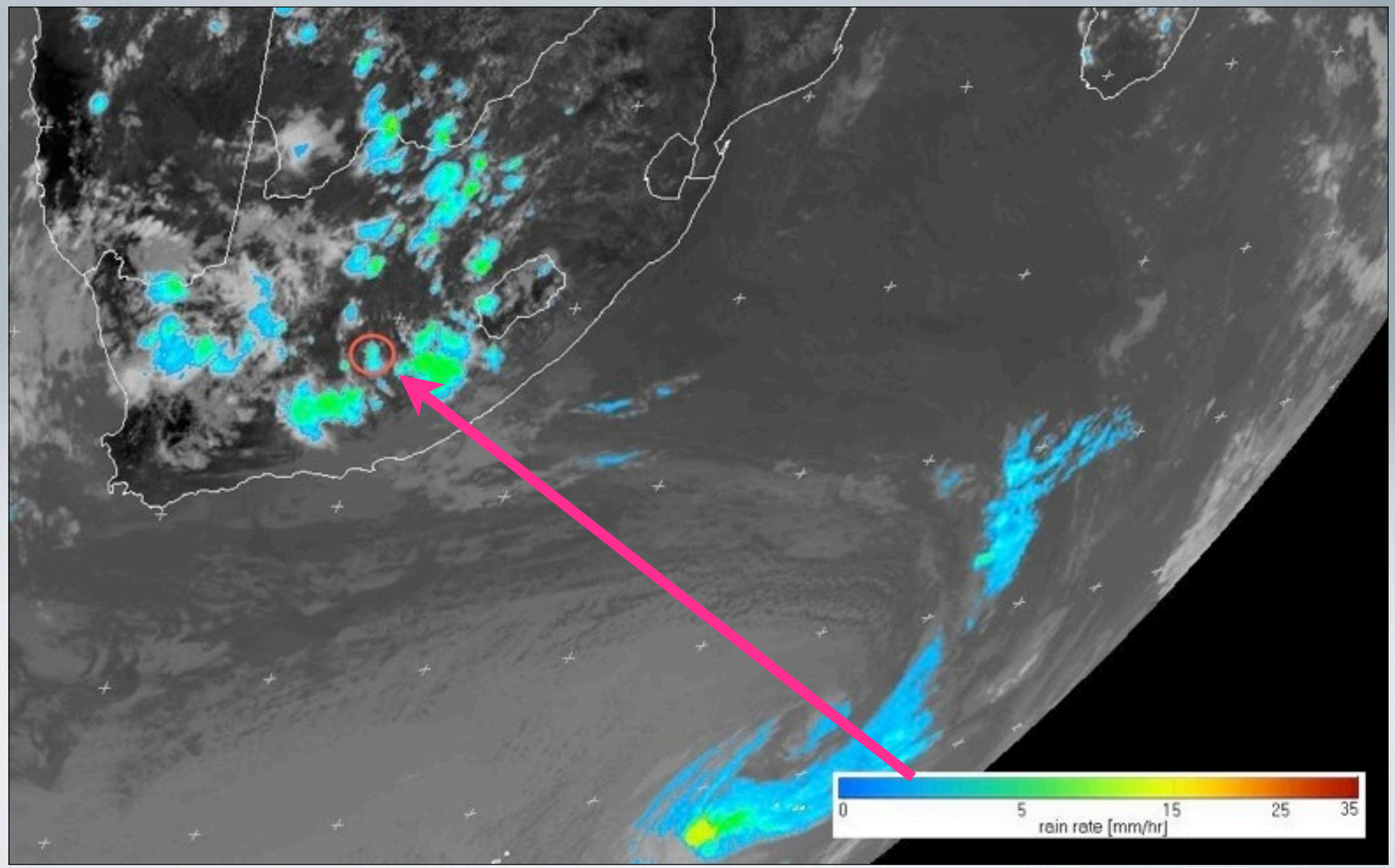
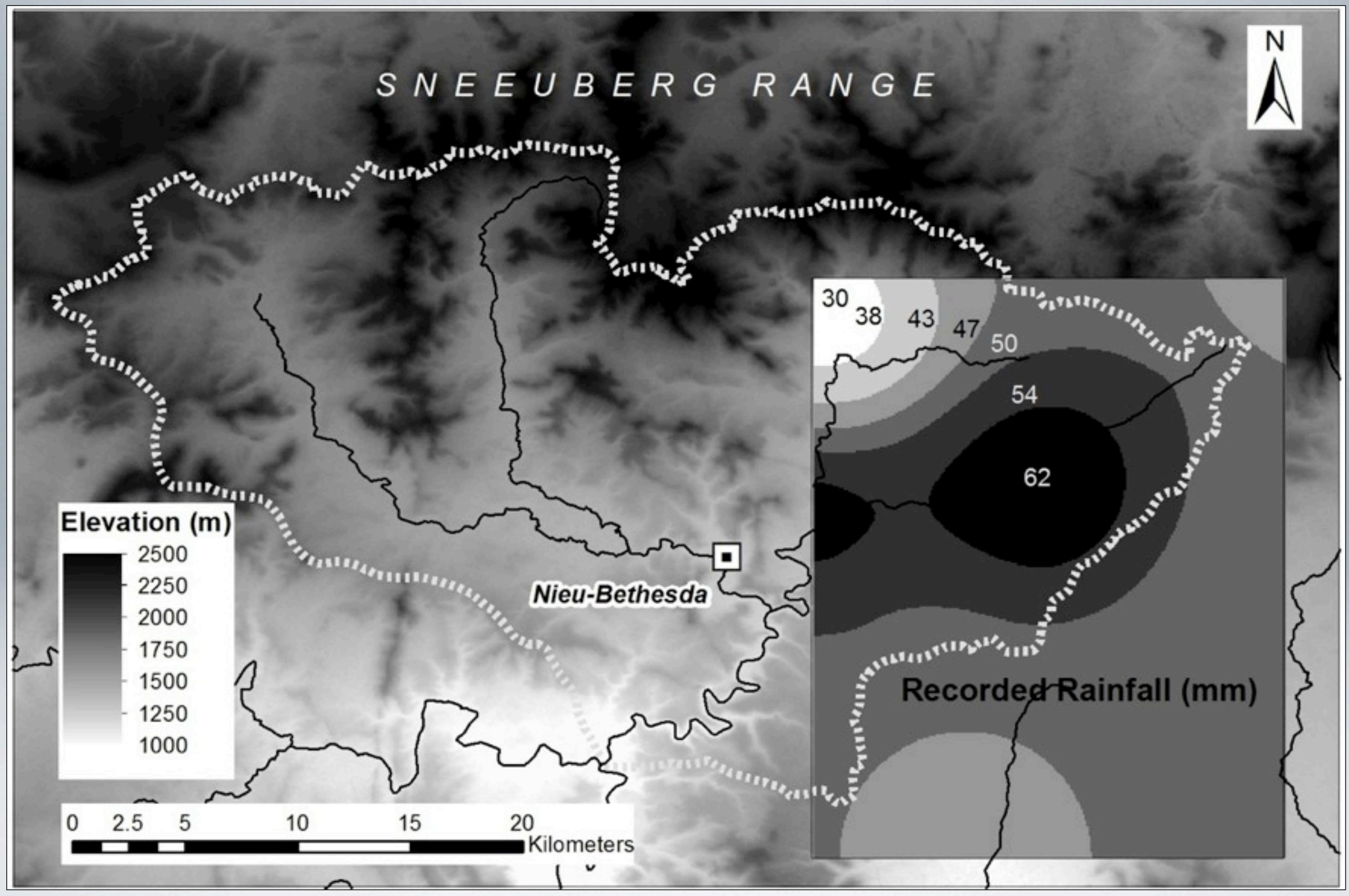
- GLDAS plot is a much better ‘fit’ with the actual spatial variation and follows the altitudinal zonation.

- Both the GLDAS and TRMM products underestimate the amounts of precipitation, as does this EUMETSAT image for 15.30 on 9th February .....



12TH FEBRUARY



- Localised in one tributary of the catchment, not related to altitude

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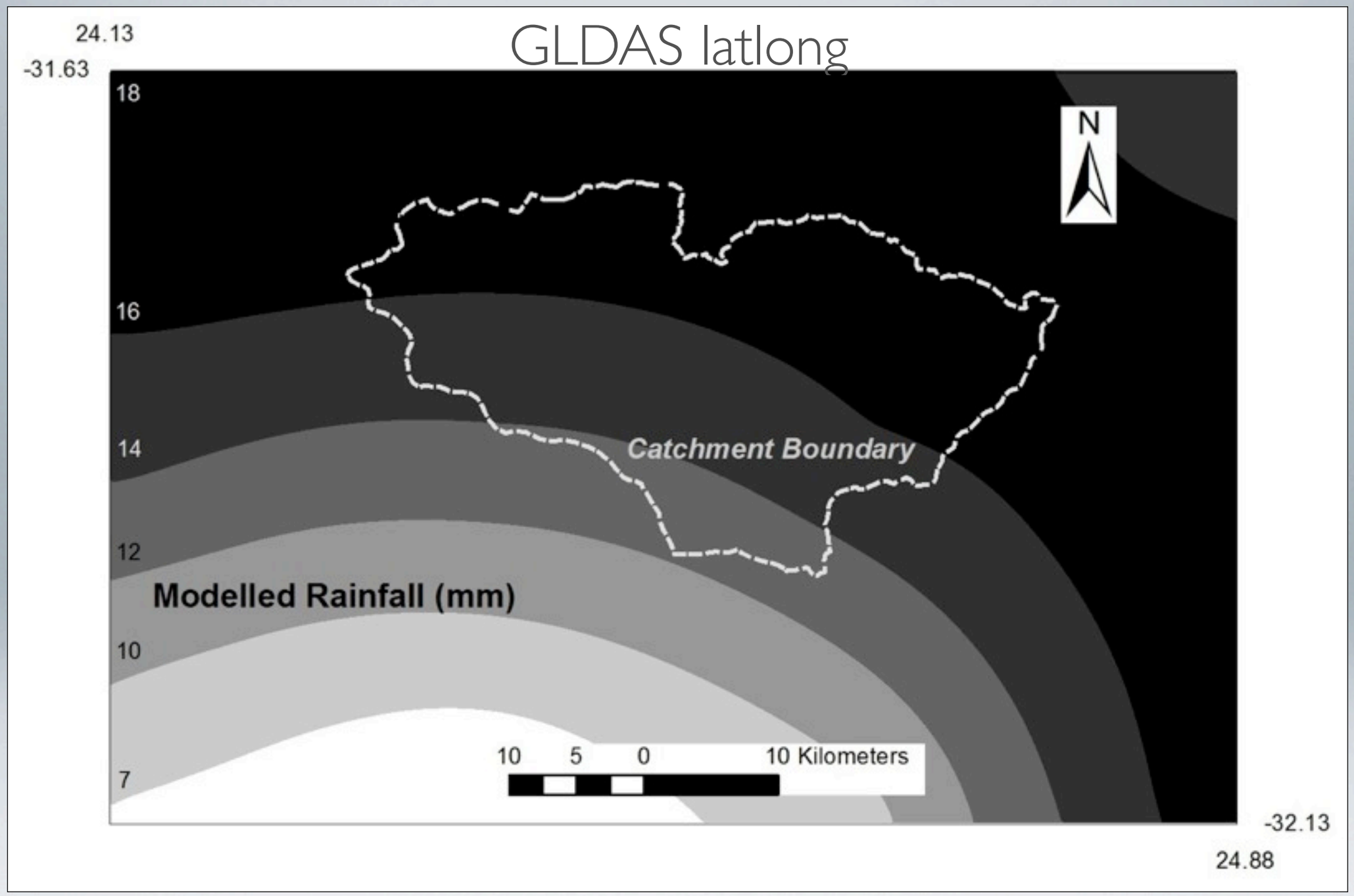
12TH FEBRUARY



- South-west to north-east trend, lower range of values (7-18 mm)

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CONCLUSIONS

The Giovanni website (Kempler 2012) notes in its FAQs concerning using TRMM precipitation products:

> Occurrence of precipitation over land tends to be underestimated, because satellite schemes tend to miss light precipitation and precipitation that is enhanced by flow lifting over mountains.

Our own analyses certainly corroborate this statement as the sections above have demonstrated underestimation for different temporal regimes and for spatial variation. Liu *et al* (2012) also found that the TRMM RB42 data were poor estimates of daily rainfall both spatially and temporally and they were especially deficient at estimating large storms. Our findings are in agreement with this.

- The newly released GLDAS data gives a much closer spatial correspondence for one of the two events.

- 10 year rainfall events have increased their intensity in the broader region since the 1930s by 20-30%.

- 50 year daily rainfall increased from 71 to 84 mm (Cranemere) and 70 to 115 mm (Middleburg).

- Floods of 9th and 12th February were produced by intensities similar to those quoted above, modelled information can seriously underestimate extreme events

- Extreme events such as 1961, 1974 and 2011 are likely to become more intense and damaging (predicted for this part of South Africa).
  - impact on movement of sediment down the hydrological system;
  - impact on agricultural systems.

- Study has introduced new data into literature comparing actual with modelled information and it is at a finer spatial scale.

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THANK YOU

Roddy Fox & Kate Rowntree