

Quantifying Weather and Climate Impacts on Health in Developing Countries (QWeCI)



A Seventh Framework Programme Collaborative Project (SICA)

13 partners from 9 countries

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Grant agreement 243964

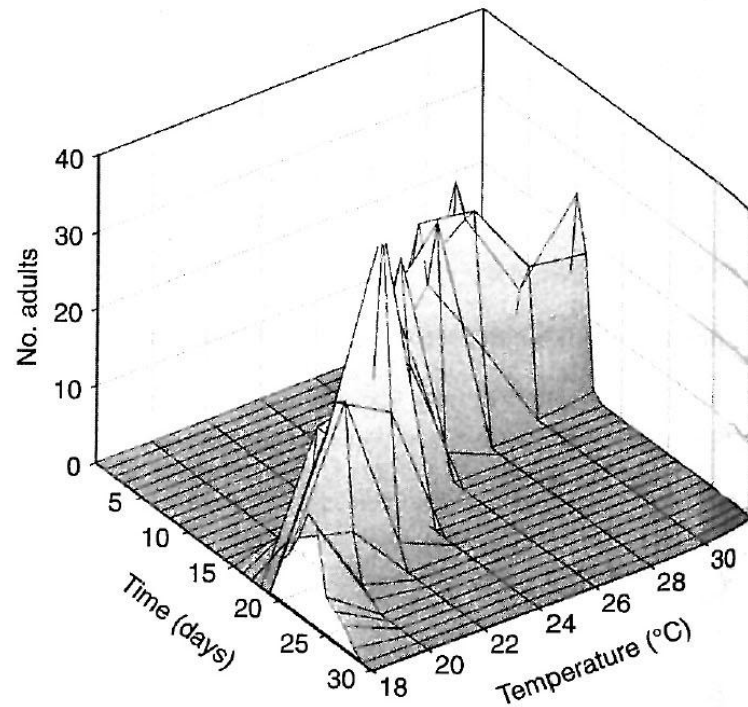
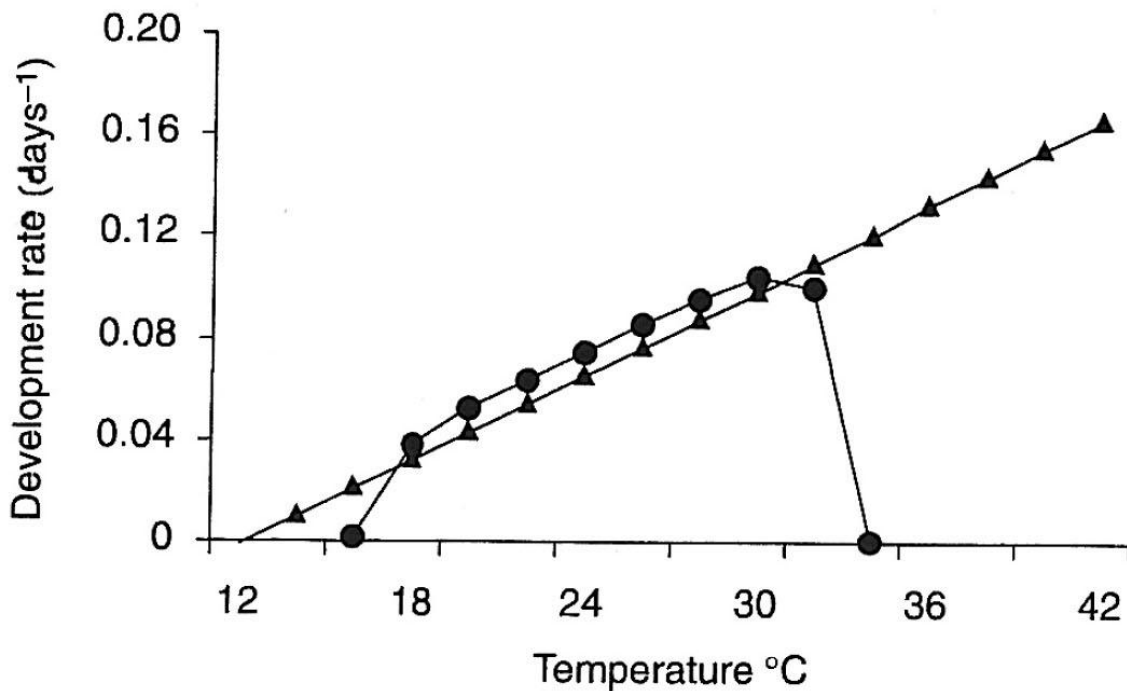
Correlation of water temperatures of temporary water bodies with atmospheric temperatures in the Kumasi region

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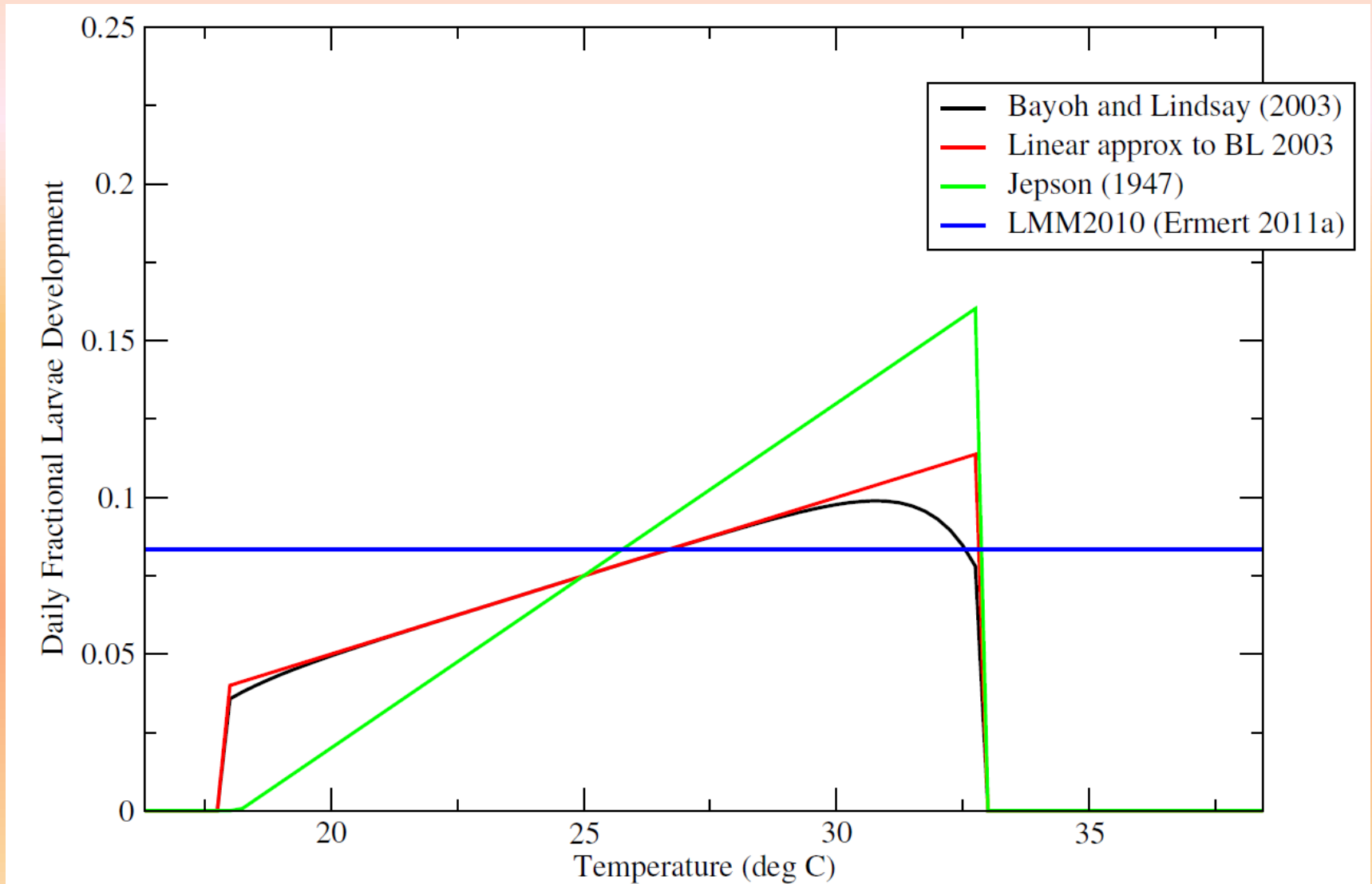
Larvae development of *Anopheles gambiae sensu stricto*



Left: Comparison of a linear degree-day model of relationship between temperature and development rate of *Anopheles gambiae* mosquitoes (Craig et al. 1999) with the non-linear model produced by Bayoh and Lindsay (2003).

Right: Three-dimensional view of the influence of temperature on adult *Anopheles gambiae* s.s. emergence times and numbers produced (source: Bayoh and Lindsay 2003, Figs. 4 & 5)

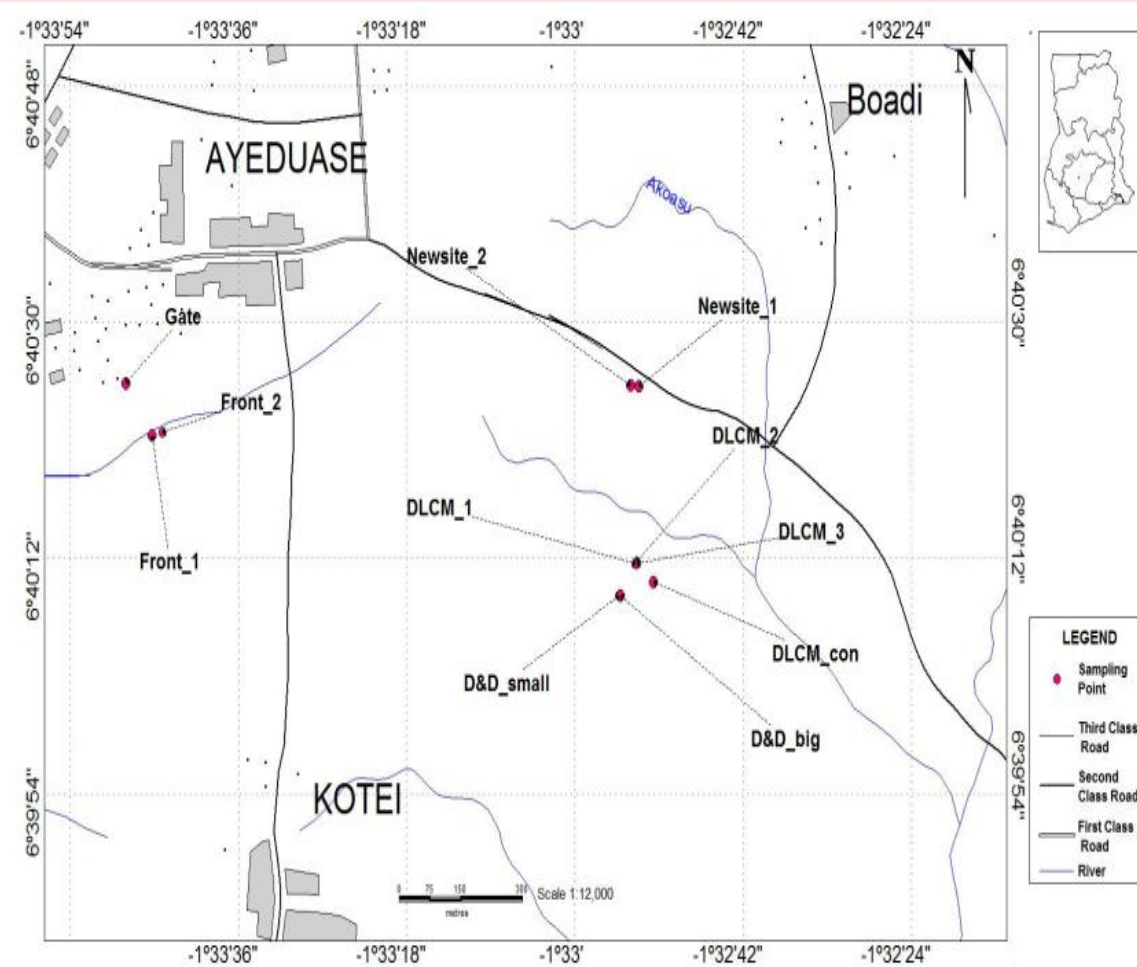
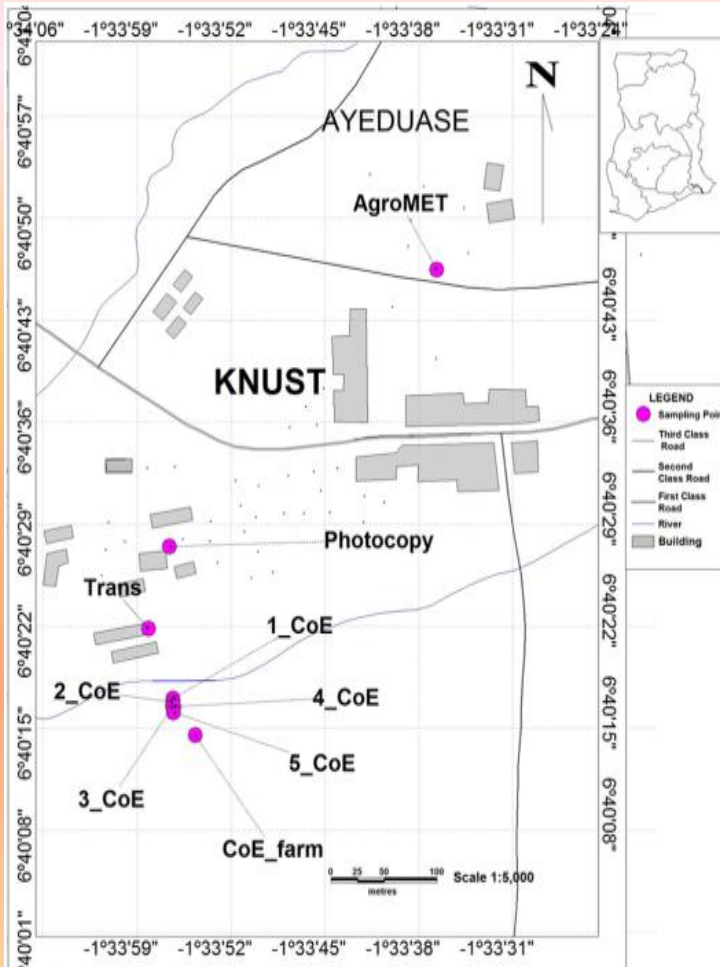
Larvae development rates in malaria models



Larvae development rates as a function of temperature as modeled by **Bayoh and Lindsay (2003)** (black/red), **Jepson 1947** (green) and **Ermer et al. 2011** (blue). All three linear forms are implemented in VECTRI.

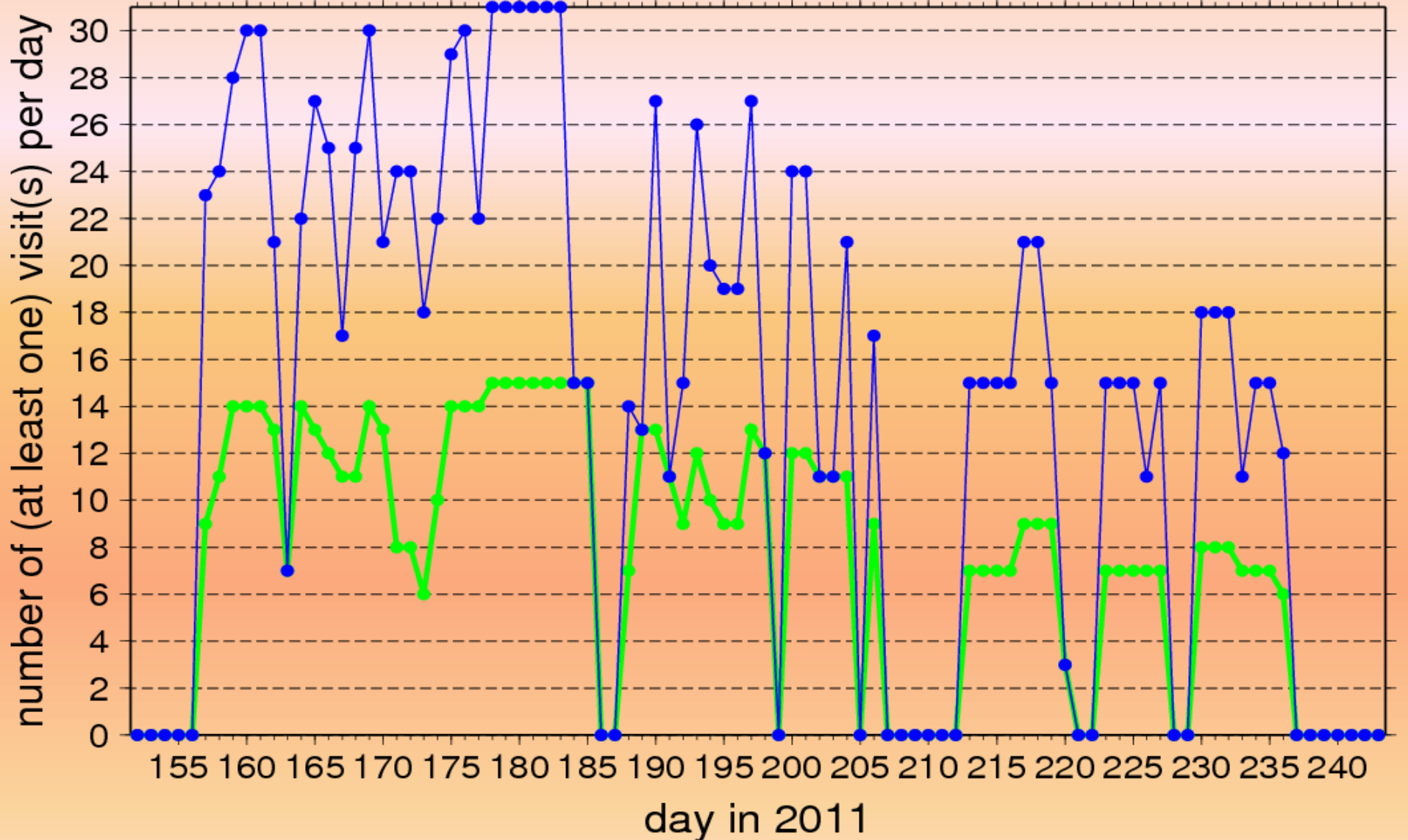
DATA

Temporary water bodies in the Ayeduase and Kotei quarters of Kumasi



Locations of visited temporary water body sites (source: Ernest Asare).

Visits at the temporary water bodies



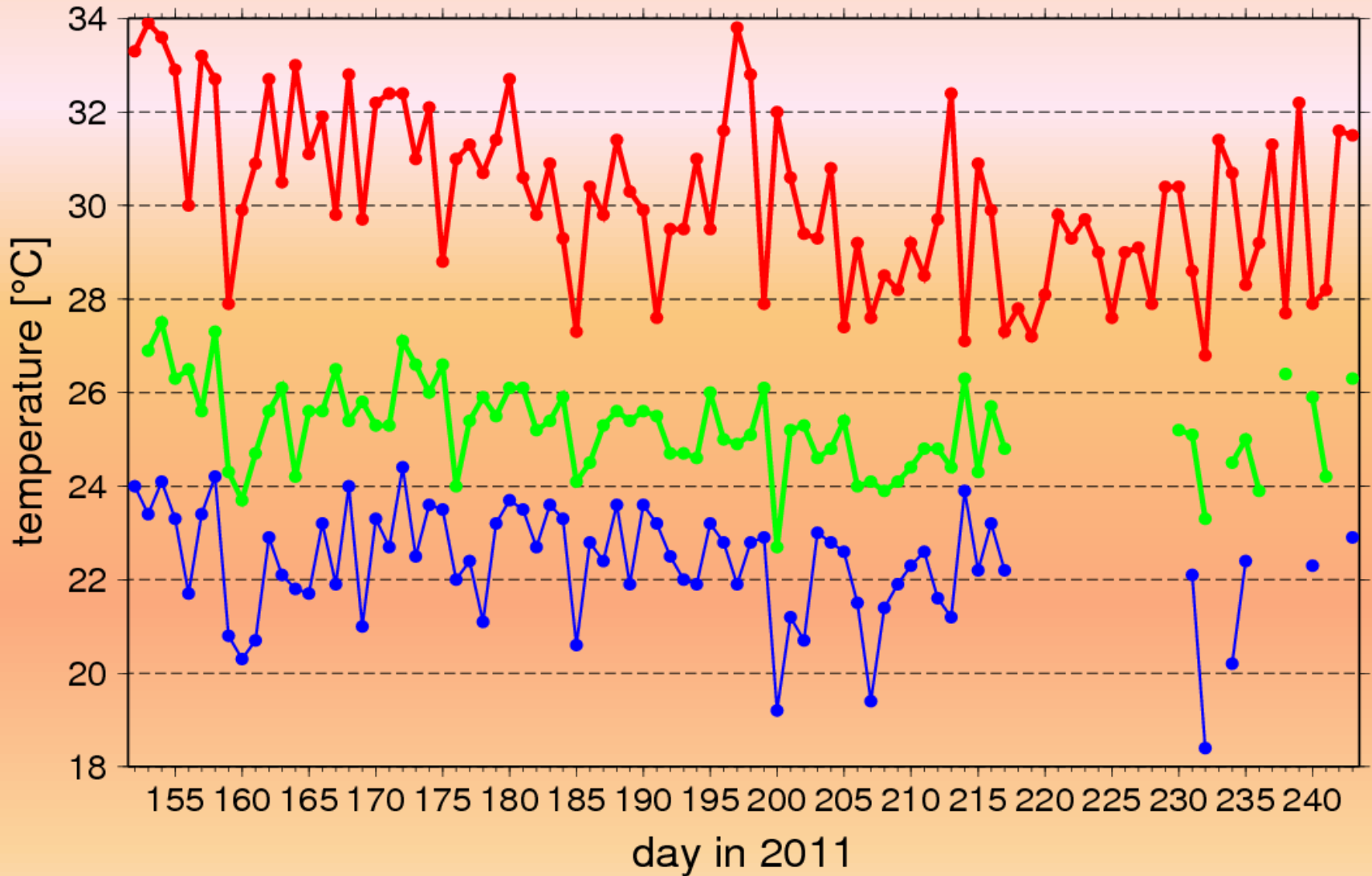
Number of performed temporary water body site observations per day (blue line and dots, and number of at least one visit per water body per day (green line and dots) between June and August 2011.

Temporary water bodies in the Ayeduase and Kotei quarters of Kumasi

Number	Name	Easterns	Northens	Elevation [m]	Visiting time [UTC]	Dimension [cm ²]
1	1_CoE	658550	737654	259	10/13/16	23,595
2	2_CoE	658551	737646	258	10/13/16	29,948
3	3_CoE	658550	737638	257	10/13/16	64,612
4	4_CoE	658553	737637	256	10/13/16	60,024
5	5_CoE	658552	737624	258	10/13/16	32,691
6	CoE_farm	658602	737577	256	10/13/16	14,440
7	Photocpy	658541	737975	280	11/13:30/16:30	42,033
8	Trans	658494	737801	266	10/13/16	22,359
9	Newsite_2	660462	737909	282	07:30/13:30	50,344
10	Newsite_1	660489	737907	283	07:30/11:30	115,434
11	DLCM_1	660480	737492	259	08:30/12	17,600
12	DLCM_2	660484	737496	260	08:30/12	73,407
13	DLCM_con	660539	737448	263	08:45/12:15	80,745
14	DLCM_3	660483	737491	262	08:30/12	80,745
15	D&D_big	660430	737416	268	09/12:15	570,000

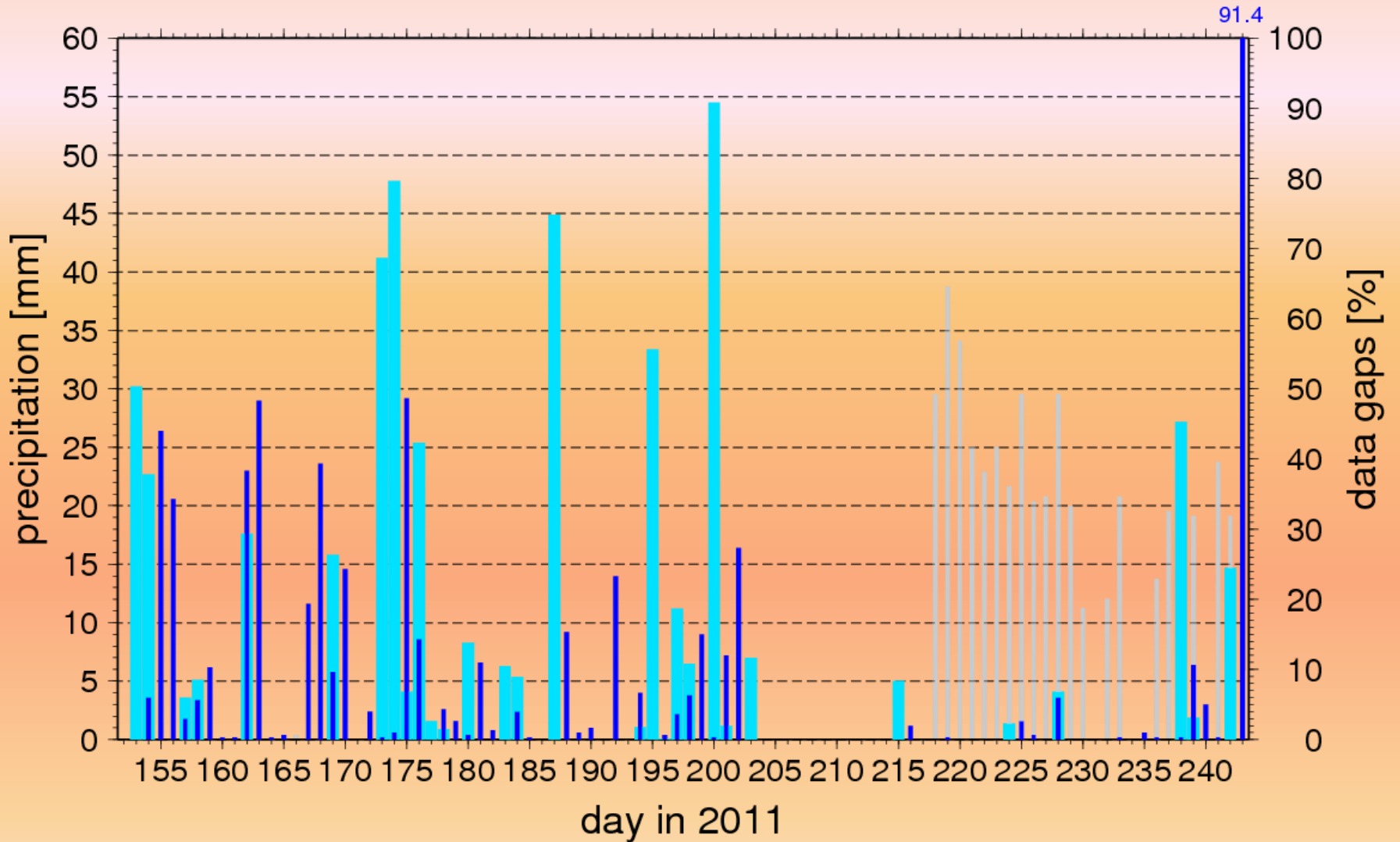
*Latitudinal and longitudinal positions (in terms of the **World Geodetic System 1984 (WGS 84)**, **Universal Transverse Mercator (UTM)**, zone 30N), elevation, visiting time, and average dimensios (in cm²) of the 15 temporary water bodies.*

Temperature observations from the Owabi AWS



Minimum (blue line and dots), maximum (red line and dots), and daily mean temperature (green line and dots) observations from the OwabiAWS between June and August 2011 (Julian calendar).

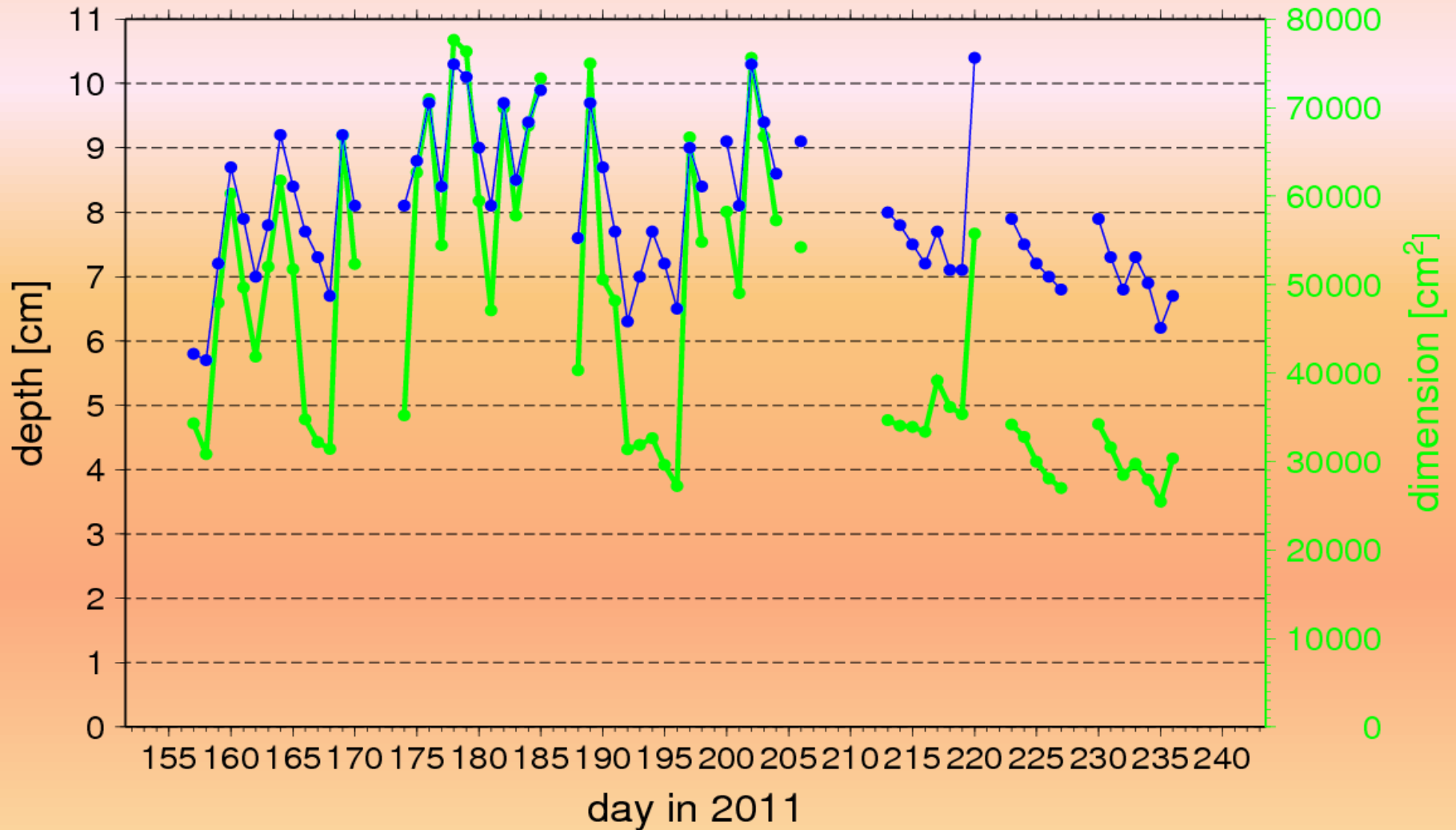
Rainfall measurements from the Owabi AWS & Kumasi airport



Observed precipitation amounts at the OwabiAWS (thin dark blue bars) and Kumasi airport (thick light blue bars). Data gaps (right axis; in percentages per day) of the OwabiAWS are marked by thin dark grey.

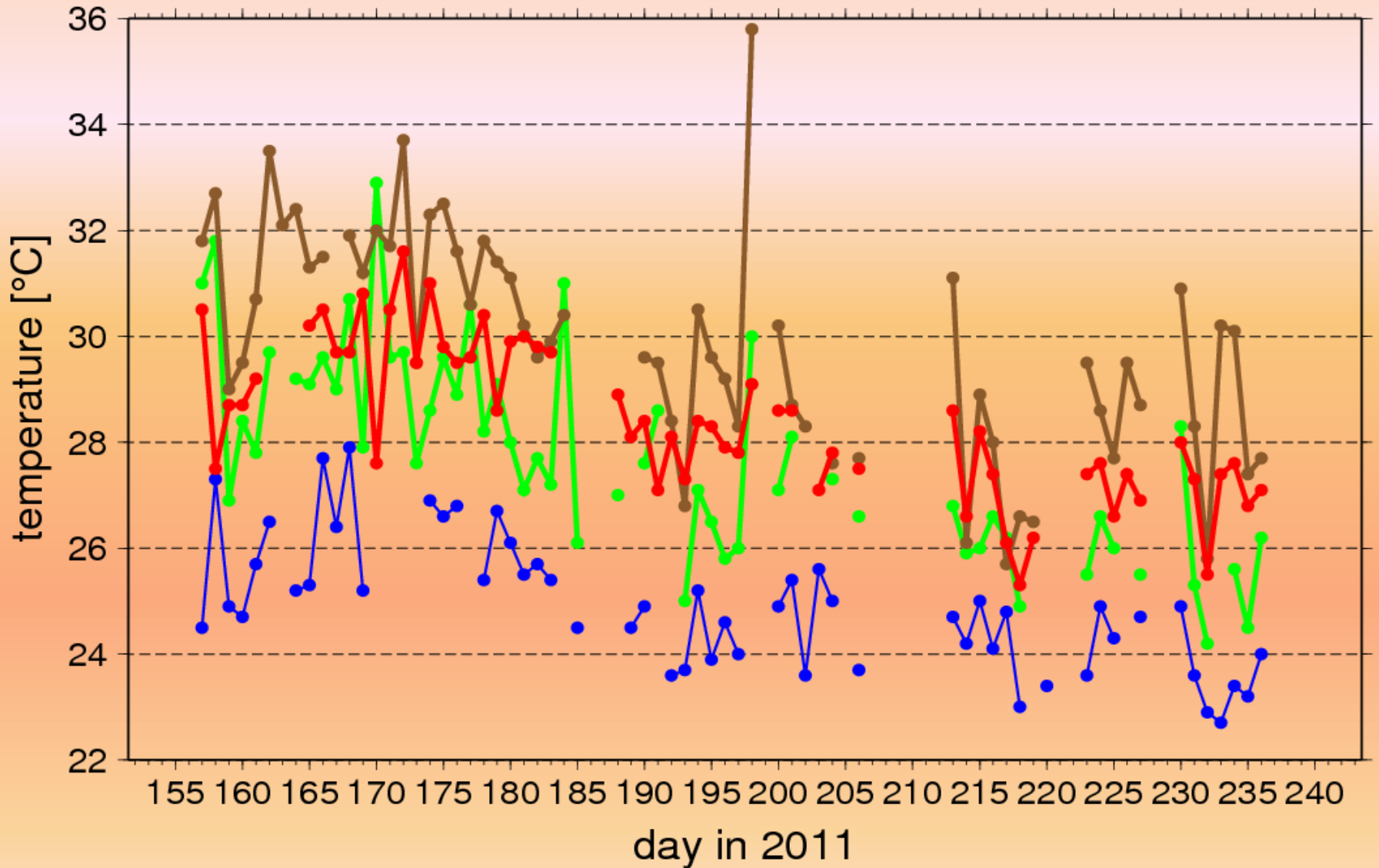
RESULTS

Depth and dimension of the temporary water bodies



Averaged depth (in cm; site 6 is excluded) and dimension (in cm²; sites 6, 11, and 15 are excluded) of temporary water bodies within the Ayeduase and Kotei quarters of Kumasi between June and August 2011 (Julian calendar).

Water temperatures of temporary water bodies



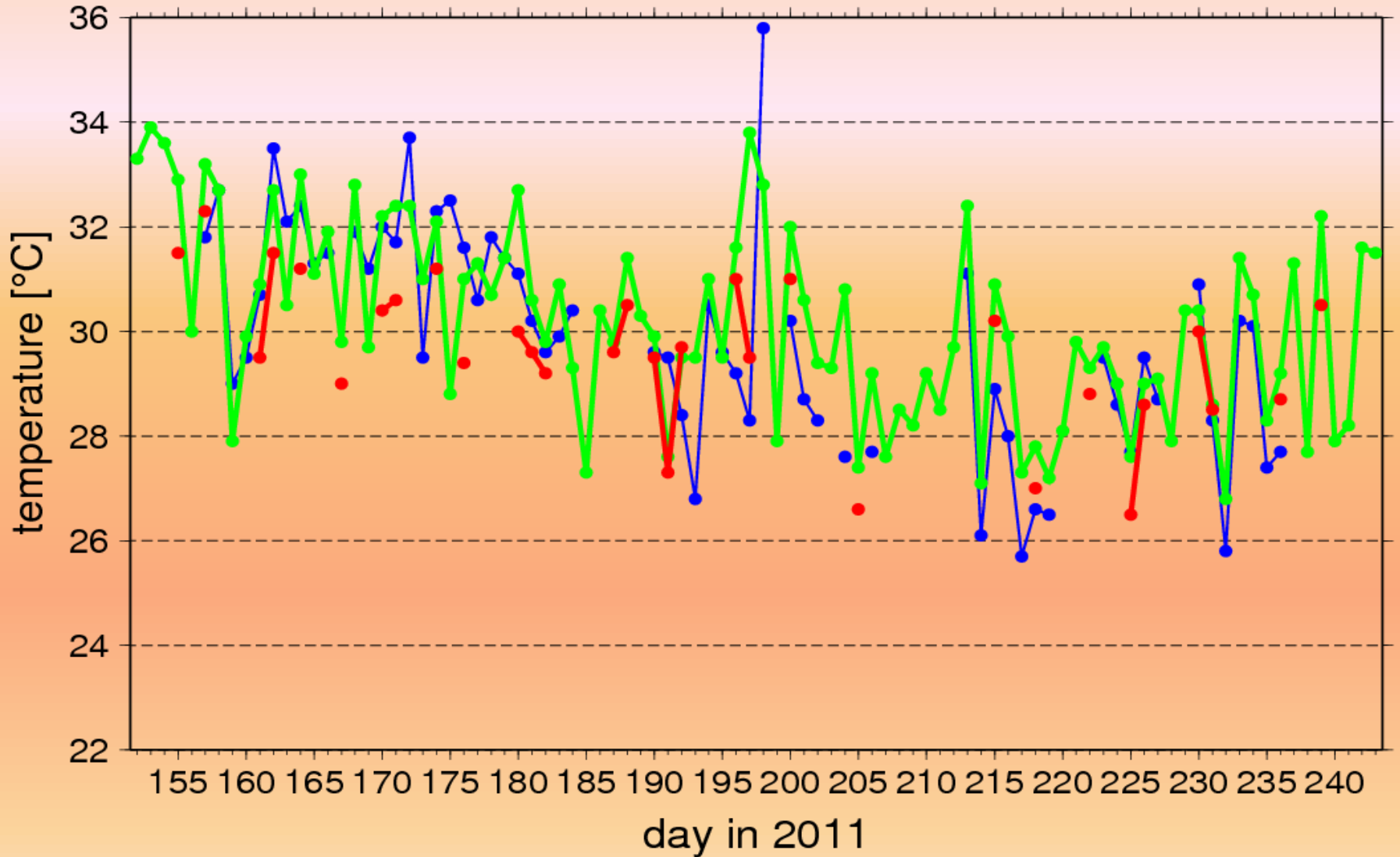
Water temperatures during the morning (blue line; 07:30-09:00 UTC), late morning (green line; 10:00-11:30 UTC), lunchtime (brown line; 12:00-13:30 UTC), and afternoon (red line; 16:00-16:30 UTC) hours.

Temperature observations from the Owabi AWS

Visiting time	Air temperature	Linear correlation coefficient
morning (07:30-09:00 UTC)	T_{min}	0.466 (45) <i>0.518 (27)</i>
	T_m	0.435 (47) <i>0.531 (31)</i>
	T_{max}	0.494 (54) <i>0.406 (21)</i>
late morning (10:00-11:30 UTC)	T_{min}	0.441 (50) <i>0.284 (28)</i>
	T_m	0.440 (52) <i>0.458 (33)</i>
	T_{max}	0.575 (7) <i>0.501 (24)</i>
lunchtime (12:00-13:30 UTC)	T_{min}	0.315 (50) <i>0.348 (32)</i>
	T_m	0.381 (52) <i>0.284 (38)</i>
	T_{max}	0.736 (60) <i>0.738 (24)</i>
afternoon (16:00-16:30 UTC)	T_{min}	0.249 (49) <i>0.287 (31)</i>
	T_m	0.435 (51) <i>0.507 (35)</i>
	T_{max}	0.631 (59) <i>0.688 (24)</i>

*Linear correlation coefficients (r) between water temperatures and 2 m screen temperatures (T_m , T_{min} , T_{max}) observed at the OwabiAWS (**bold figures**) and Kumasi airport (*italic figures*).*

Water and air temperature observations in the Kumasi area



Water temperatures measured during lunchtime (blue line and dots; 12:00-13:30 UTC) and *maximum temperatures* observed at the **OwabiAWS** (green line and dots) and at the **Kumasi airport** (red line and dots).

Summary and Conclusions

Data

- **Sites.** Temporary mosquito breeding sites from the eastern part of Kumasi
- **Observations.** Water temperatures, depth & dimension
- **Time.** Measurements from the morning and late morning hours, from lunch time and from the afternoon
- **Weather observations.** Atmospheric temperatures from the Owabi AWS and Kumasi airport

Correlations

- **Strongest correlations.** Between lunchtime water temperatures and maximum temperatures
- **Linear correlation coefficient (r).** Up to $r=0.74$
- **Coefficient of determination (r^2).** Up to $r^2=0.55$.

Conclusions

- Water temperatures are to a certain extent predictable by maximum temperatures
- Usage of temperature observations or modelled temperatures to compute water temperatures
- Water body temperatures can be more precisely determined in dynamical mathematical-biological malaria models.

Acknowledgements

Ernest Asare is thanked for undertaking the measurements of the pond characteristics. He is currently conducting his PhD at the *Kwame Nkrumah University of Science and Technology (KNUST)* working on the hydrology of mosquito breeding sites. Ernest's PhD scholarship was generously funded by two **International Centre of Theoretical Physics (ICTP)** programmes, namely the Italian government's funds-in-trust programme and the **ICTP PhD Sandwich Training and Educational Programme (STEP)**, which enables students from developing countries to spend four months a year at ICTP. ICTP then used QWeCI funds to extend the exchange period to 6 months.