Influence of weather sensitivity on electricity consumption in Abidjan, Cotonou and Lomé, three Coastal Cities in Western Africa

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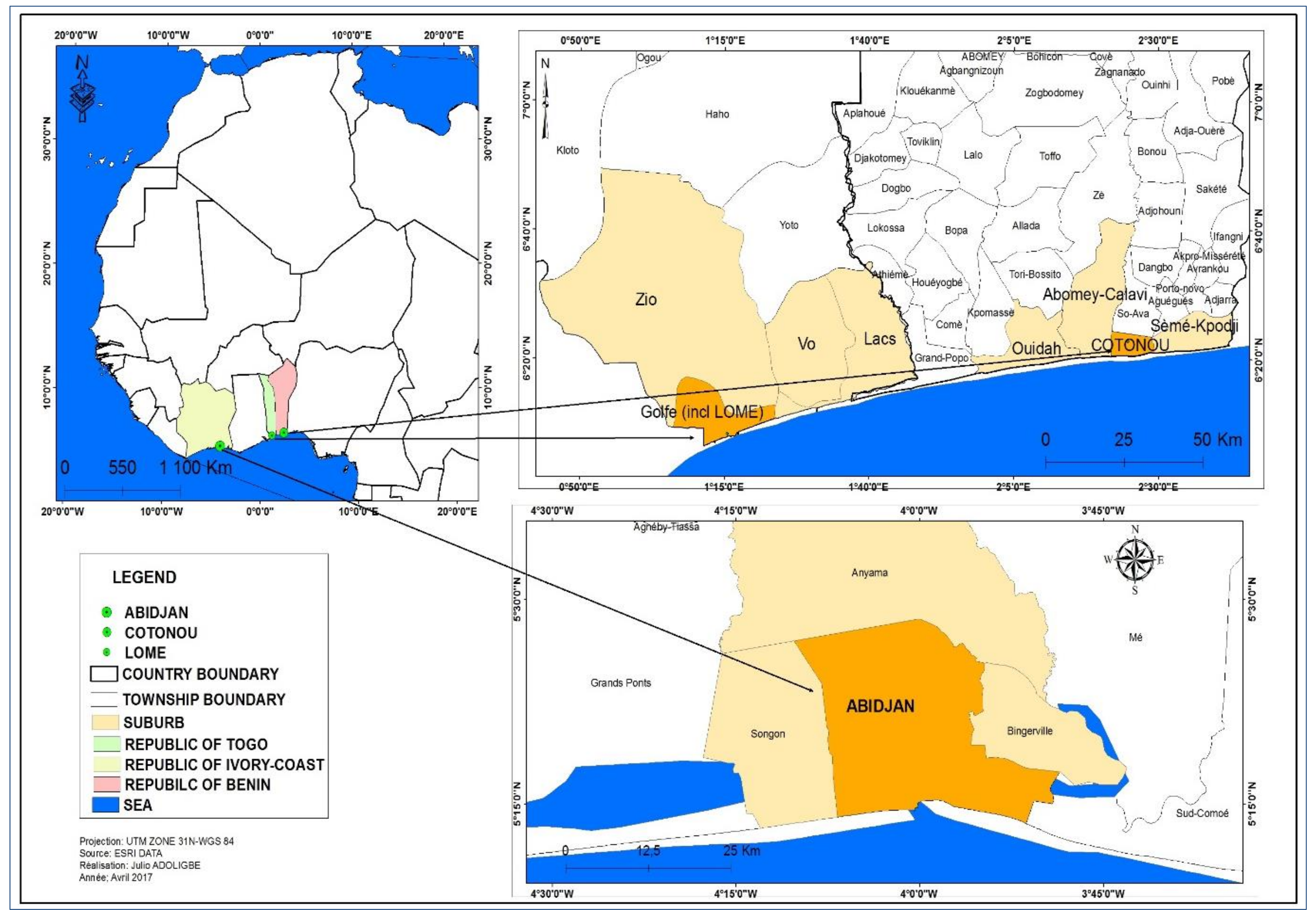
Background and Context

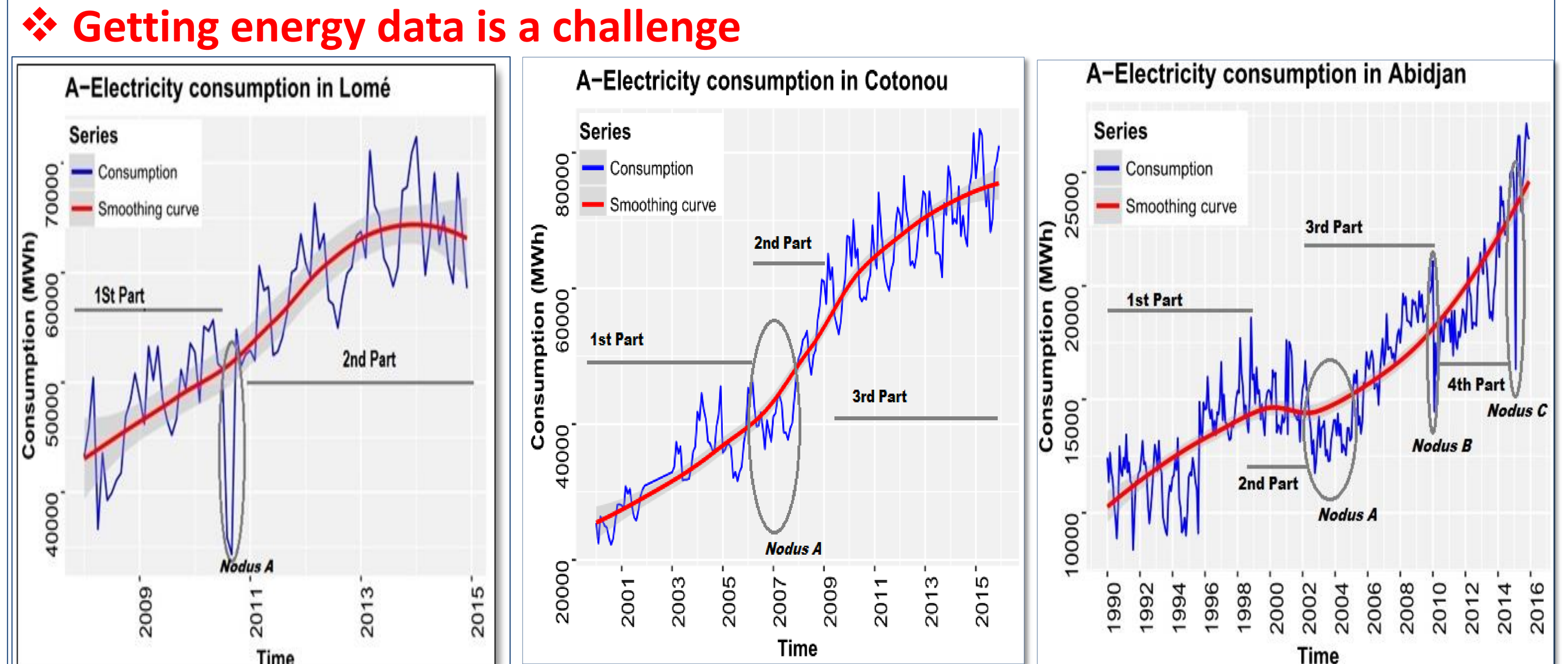
- Low carbon economy requires massive development of VRE which depend on weather.
- Power system sensitivity to weather variability (Hence the electricity consumption (***E.C***) too).
- From published of regions worldwide, electricity consumption can depend on air temperature, relative humidity, wind speed or daylight time.
- Need for understanding how electricity consumption is related to weather variables in the context of Climate change.
- The present work, explore how weather variability has driven the electricity consumption of western Africa's coastal cities in the last years using Cooling-Degree-Days (CDD).

Study case: Tree coastal cities in West Africa



Data and Analysis Methods (1| 2)

- **Electricity consumption (raw data : monthly means)**
- **Getting energy data is a challenge**

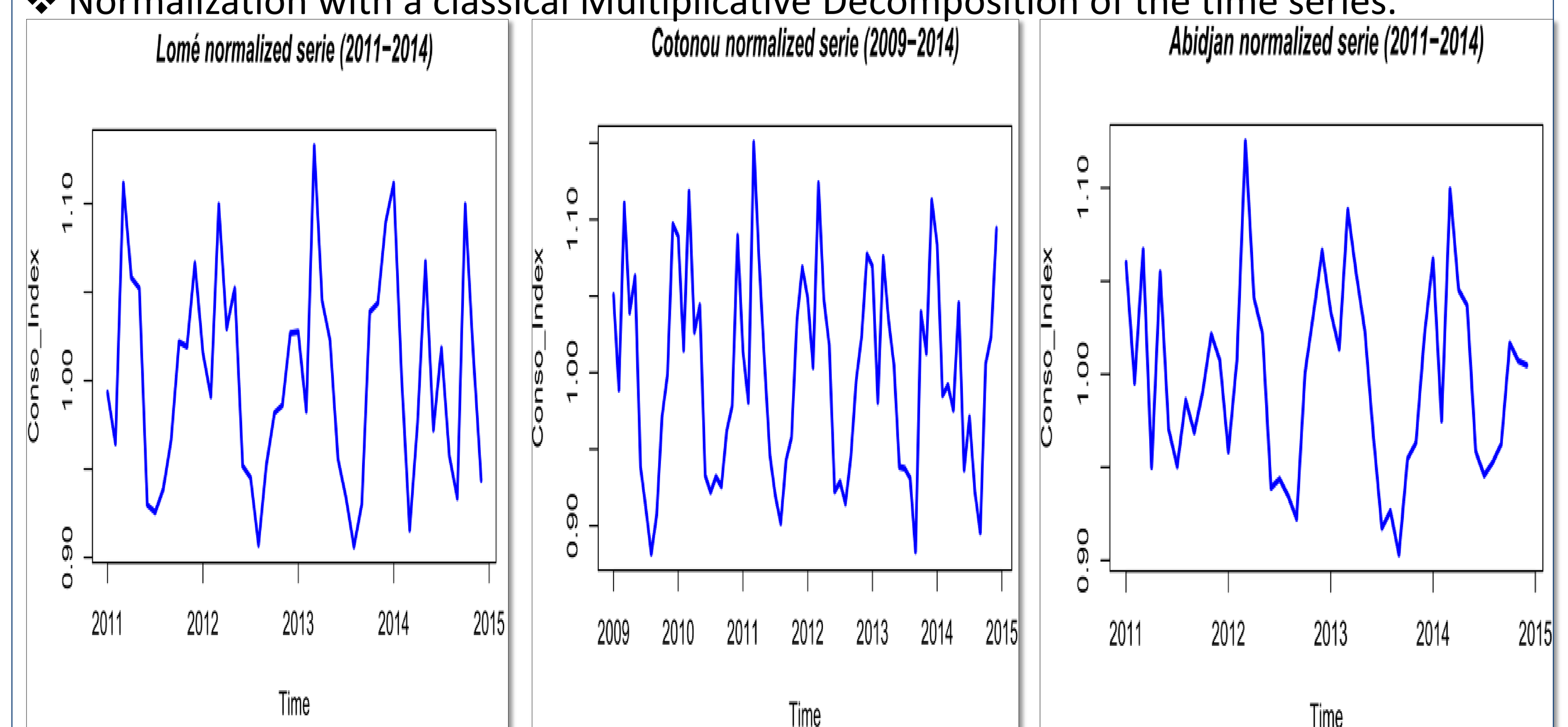


Lomé (2008-2014) | Cotonou (2000-2015) | Abidjan (1990-2016)

Raw data over the whole period

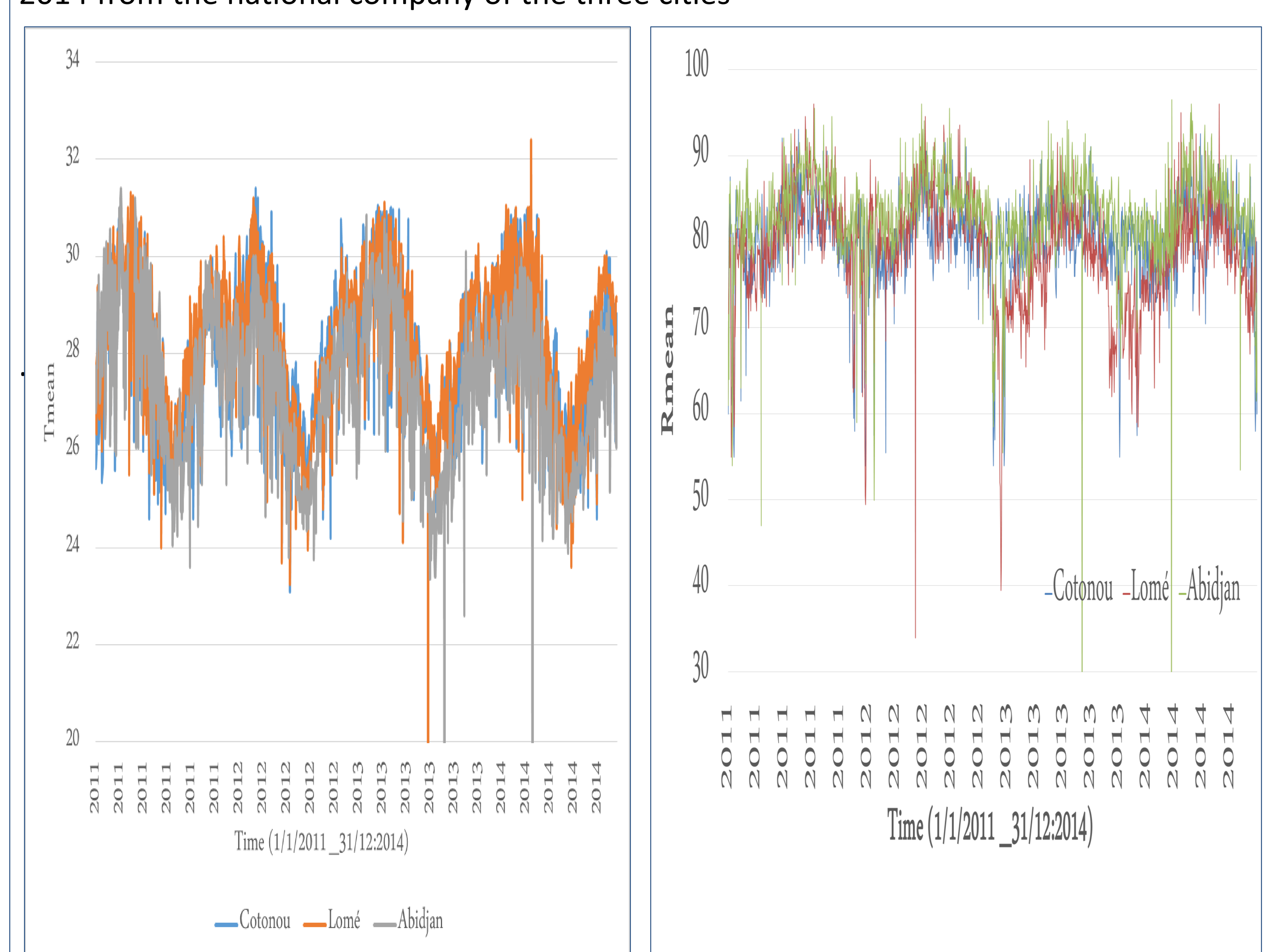
Data and Analysis Methods (2| 2)

- **Time evolution of monthly consumption is at first governed by non-climatic factors : GDP, Urbanization, population growth etc**
- Selection of homogeneous periods (2011 - 2014 for all cities), periods with no political / economical concerns
- Normalization : remove consumption drift likely related to GDP(trend
- Normalization with a classical Multiplicative Decomposition of the time series.



Normalization over the working period

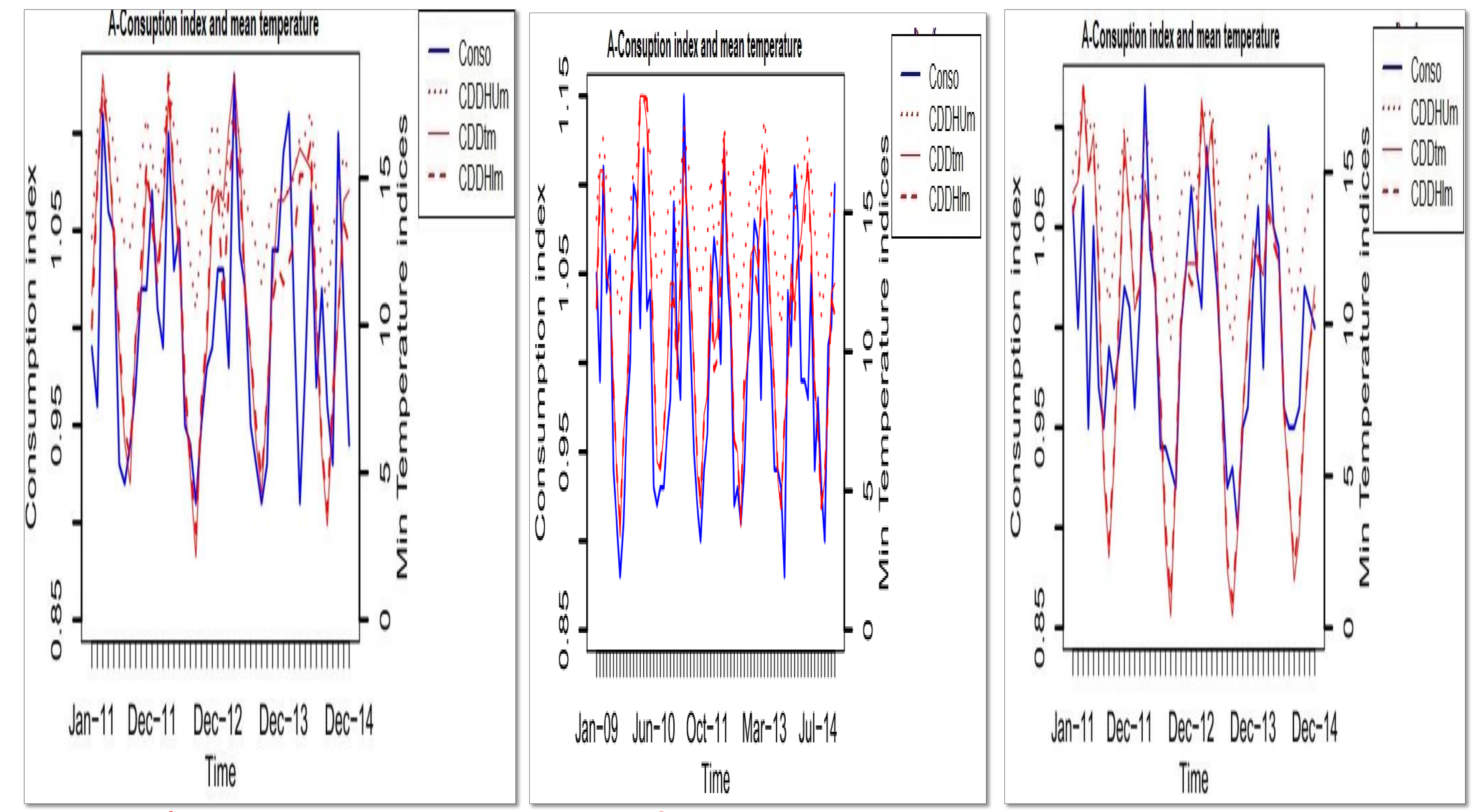
- High seasonality : (1)a peak every March (warm period; warm and dry), (2) a trough every August ("little dry season"; warm and humid)
- **Appropriate National Weather Station data is a challenging too**
- seasonality : (1)a peak every March (warm period; warm and dry), (2) a trough every August ("little dry season"; warm
- **Raw Weather data**: daily dew point; temperature , relative humidity from 1980 to 2014 from the national company of the three cities



- **Weather indexes computing**
- Humidex (HU) & Heat Index (HI), functions of temperature and Humidity
- Cooling Degree Days CDD(t) = a (T(t)-Tthreshold)

Results : Weather & consumption indexes (1| 2)

- **Inter-annual evolution of monthly CDDs and of monthly electricity consumption**



Lome | Cotonou | Abidjan

Relation between consumption and cooling degree day: an additional consumption due to buildings cooling

Pearson correlation (p-value > 0.05.) between monthly consumption (Conso_index) and temperature index CDDs .

CORRELATION MATRIX

	Conso_index	CDDtm	CDDHUm	CDDHIm	CDDTxn	CDDHUxn	CDDHIxn
Abidjan							
conso index	1.00	0.76	0.75	0.75	0.76	0.75	0.75
Cotonou							
conso_index	1.00	0.78	0.73	0.75	0.78	0.73	0.78
Lomé							
conso_index	1.00	0.66	0.59	0.63	0.66	0.59	0.63

Better links in Abidjan and Cotonou

Conclusion & Perspectives

For the three (3) cities :

- Strong relationship between temperature with increased consumption in hot weather conditions
- Influence of relative humidity for Cotonou and Abidjan
- Heat index and temperature : better explanatory power than

Further investigations

Electricity demand Model

Approach similar to Scapin et al.,2016 & Waite et al.,2017

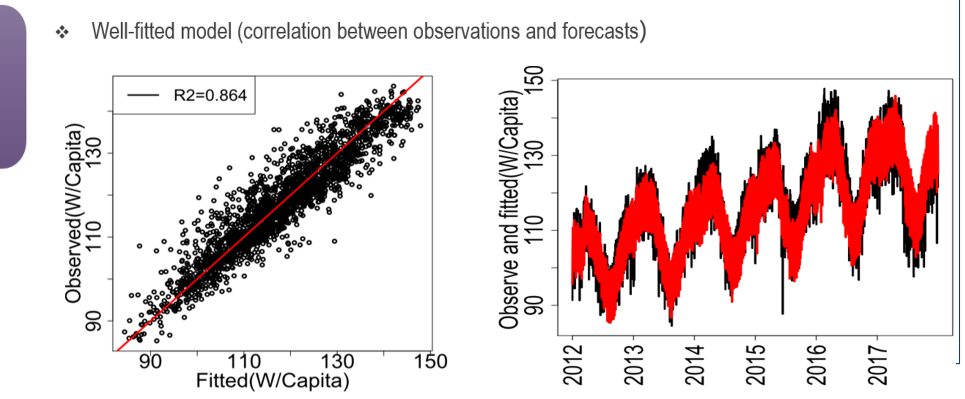
$$C(t) = \left\{ C0 + \beta 0.IT(t) + \beta 1 IRH(t) + \sum_{i=1}^{7} \gamma i.IJi(t) + \varepsilon(t) \right\} * f(t)$$

With
C(t) : per capita consumption for day t.
f(t) : temporal trend
C0(t) : basis consumption [W/Capita].
β 0(t) : temperature-sensitivity [W/°C/Capita].
β1(t) : humidity-sensitivity [W/%/Capita]

With
γi(t) (i=7) : daily factors [W/Capita].
IT(t) : Cooling Degree Days [CDD, °C]; IRH(t) : Humidity Index [%]
IJ(t) : weekday dummies with IJ = 1. 2. 3. 4. 5. 6. 7 for Mondays. Tuesdays. ... & Sundays and holidays together.
Ɛ(t) : residuals

Results : drivers & weather sensitivity

- Well-fitted model (correlation between observations and forecasts)



Predicted versus observed consumption _ Abidjan | Predicted (red) and observed (black) times series of daily consumption of Abidjan (2012-2017)

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