Study on the local sea water temperature variation for the industrial water use of Al-Zour coastal area in Kuwait

Myung Eun Lee

Deputy General Manager

R&D Center, Hyundai Engineering and Construction

Overview

- Introduction
- Hydrodynamic Model Setup
- Simulation without Thermal Discharge
- Simulation with Thermal Discharge
- Conclusion and discussion

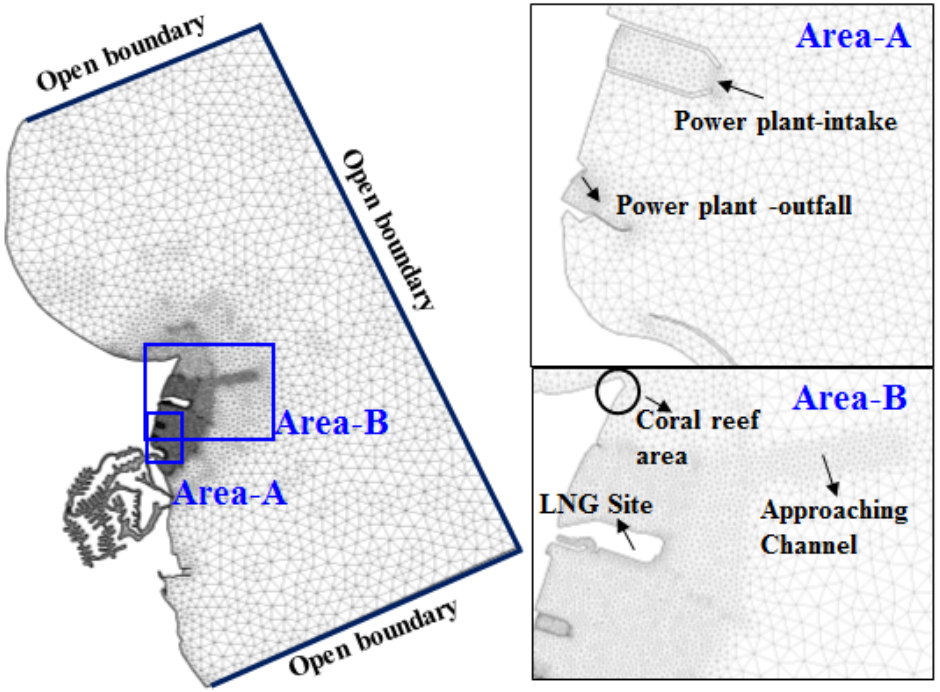
Introduction

- Al-Zour area is one of the major industrical complex in Kuwait, where Al-Zour LNG import facility is under construction by HDEC.
- The site is located near the power plant from where the great amount of thermal and brine water discharge into the sea.
- Al-Zour LNG facility will use sea water for their regasification process and cooling for compressor.
- Due to the design criteria of each process, the upper and under limit of entrained sea water is crucial factor for their equipment.
- HDEC found the high rate of flucation in local sea water due to the neighboring thermal effluent and redefined the design water temperature.

Cont., Introduction

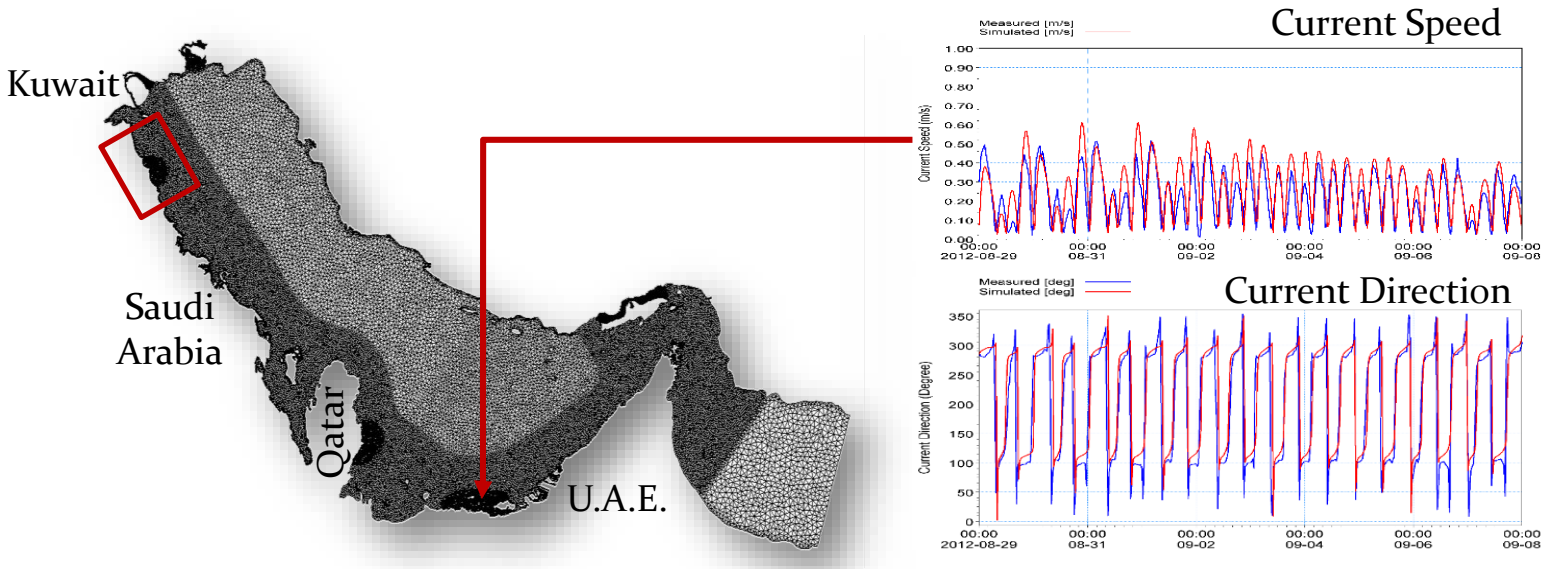
Hydrodynamic Model Setup

- Hydrodynamic and thermal study in Al-Zour site was carried out by using MIKE 3-FM of DHI
- The model covers 20 km towards shoreline and 35 km along-shore line.
- Bathymetry data was applied from MIKE C-MAP
- Minimum grid size is 20m, Maximum 1km at the open boundaries
- Model simulation period is June – July 2017



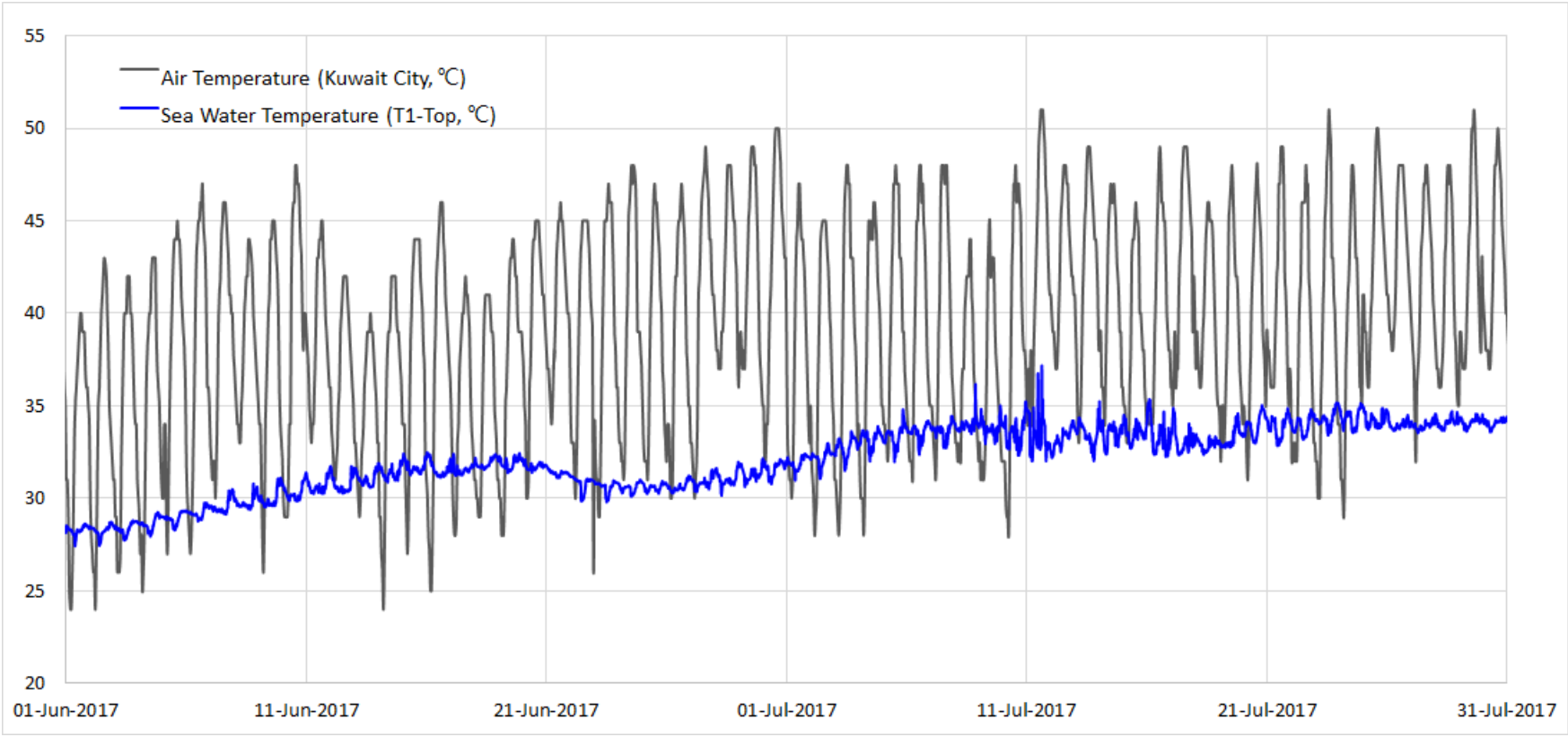
Cont., Hydrodynamic Model Setup

- Open Boundary condition was extracted from Arabian Gulf regional model



- Roughness height is a constant value 0.05 m
- Wind forcing was incorporated with ERA-5 hourly dataset provided by ECMWF
- 5 sigma layered applied for simulation

- Air temperature from inland measurement in Kuwait City & ECMWF ERA-5 Sea water temperature at the target site;



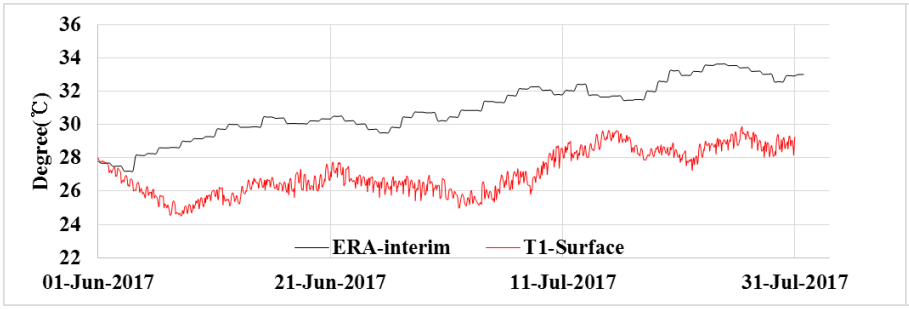
Simulation without Thermal Discharge

- Input and parameters are tuned to fit the background sea water temperature (ERA Interim) by following sequences;
  - Sequence 1. Open boundary input of SST data and + Air temperature from (both from ERA-interim data)
  - Sequence 2. Sequence 1 setup + ERA-interim short wave radiation data
  - Sequence 3. Sequence 2 setup + Heating coefficient calibration
  - Sequence 4. Sequence 3 + Inland measured air temperature

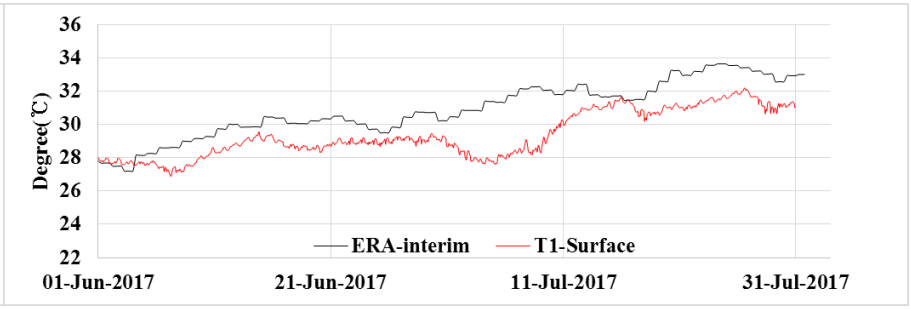
Sequence	RMSE(°C)	NRMSE(%)
1	3.95	78.5
2	1.76	34.0
3	1.27	25.2
4	0.80	13.6

Cont., Simulation without Thermal Discharge

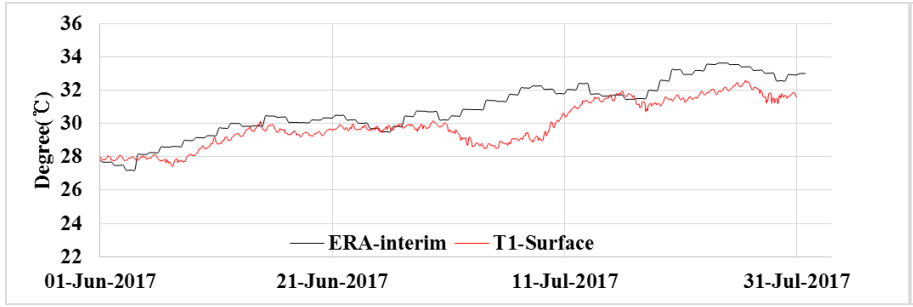
- Comparison between ERA-interim SST and simulation results;
- Short wave radiation data and air temperature were found to be a major parameters for background water temperature



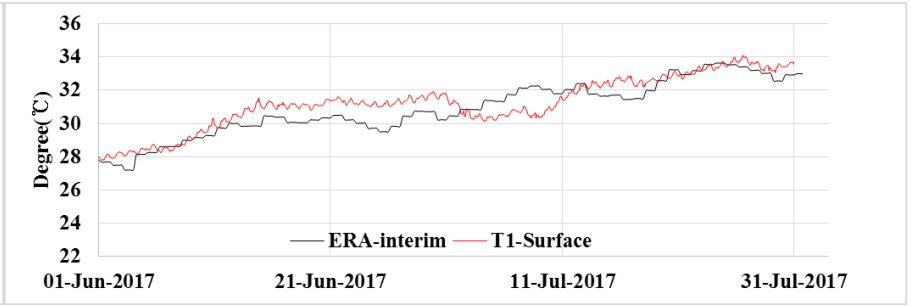
Sequence 1
(Including SST boundary)



Sequence 2
(Including Short wave radiation of ERA)



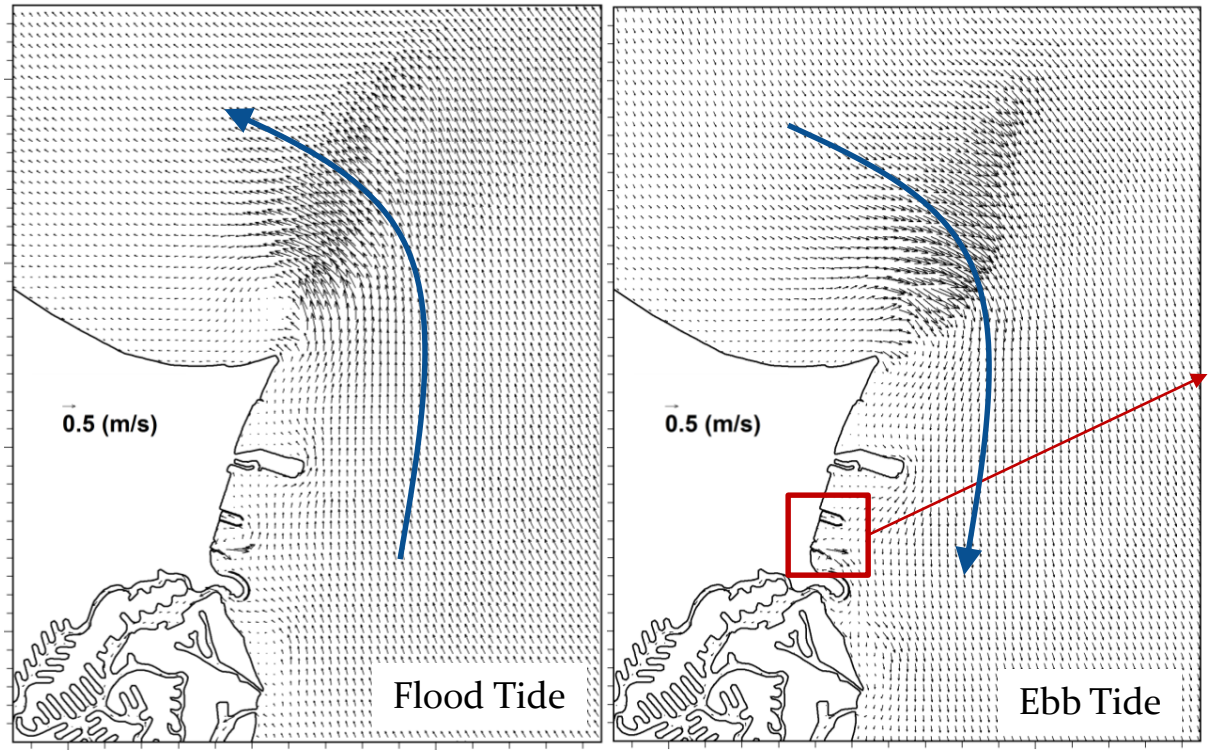
Sequence 3
(Calibration of Heating Coefficient)



Sequence 4
(Including inland measured air temperature)

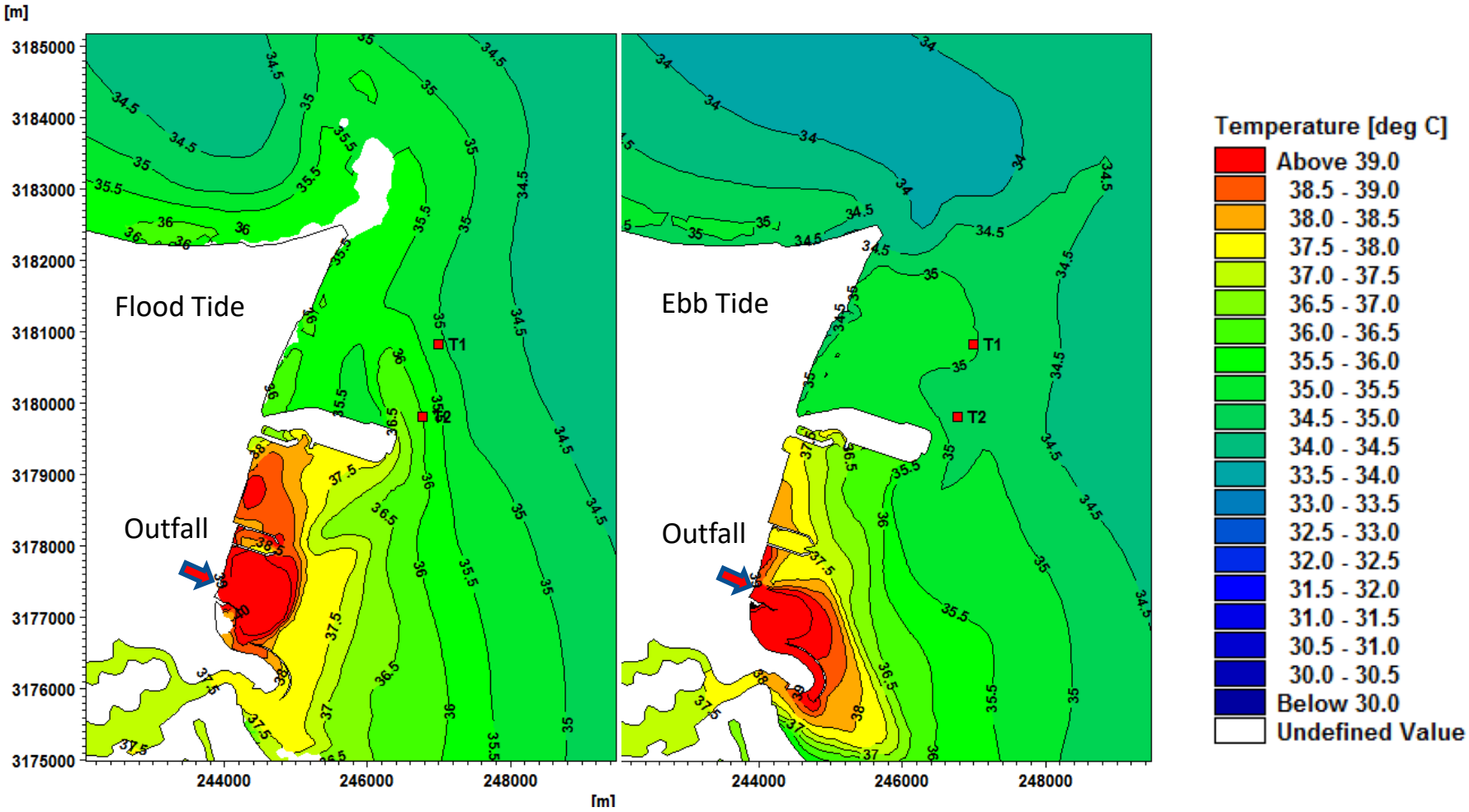
Simulation with Thermal Discharge

- Local hydrodynamic with thermal discharge in Al-Zour Coast



- Thermal discharge was set 131 m^3/s with 6°C excess water temperature

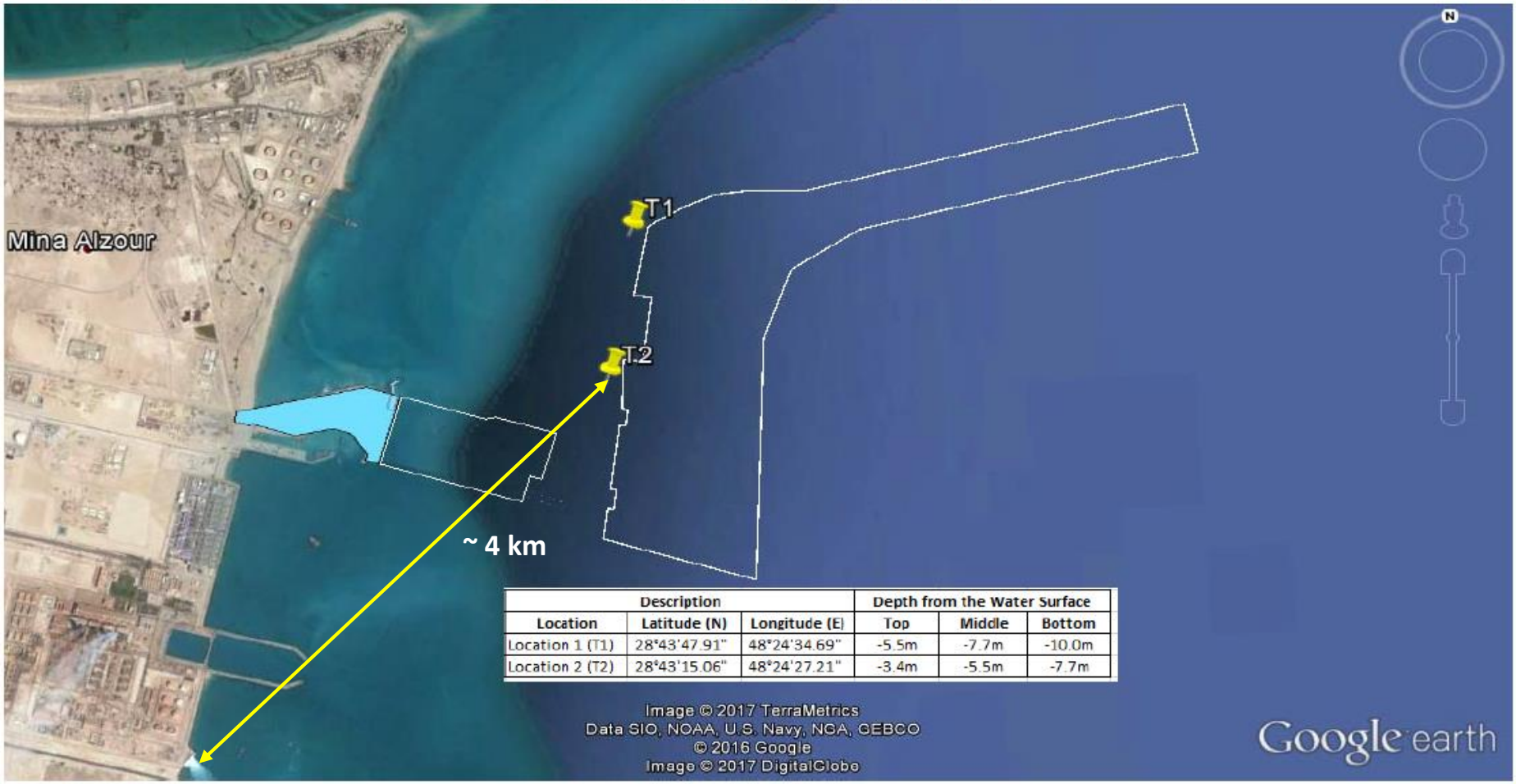
- Sea water temperature distribution with thermal discharge in flood(left) and ebb(right) tide



Measured Sea Water Temperature

- Measurement Points – Candidate locations for LNG intake head

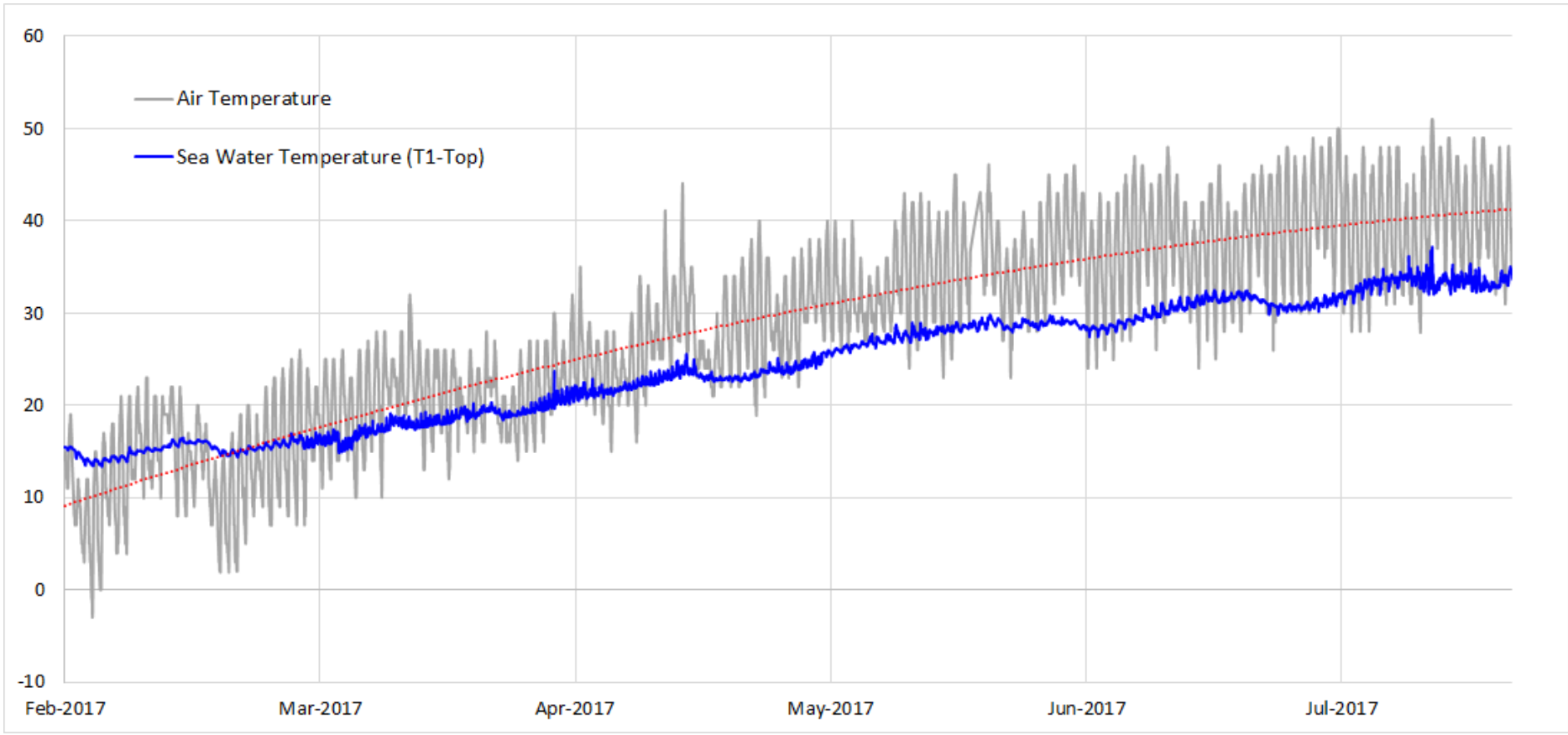
EPC0058-LNGI Marine Works-Temperature Profile



Description			Depth from the Water Surface		
Location	Latitude (N)	Longitude (E)	Top	Middle	Bottom
Location 1 (T1)	28°43'47.91"	48°24'34.69"	-5.5m	-7.7m	-10.0m
Location 2 (T2)	28°43'15.06"	48°24'27.21"	-3.4m	-5.5m	-7.7m

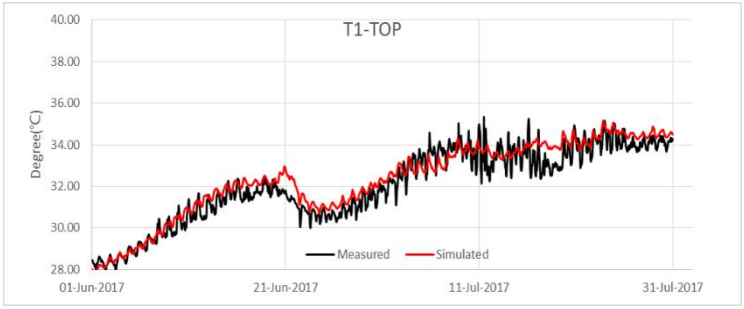
Cont., Simulation with Measured Sea Water Temperature

- Measurement Result vs. Air Temperature

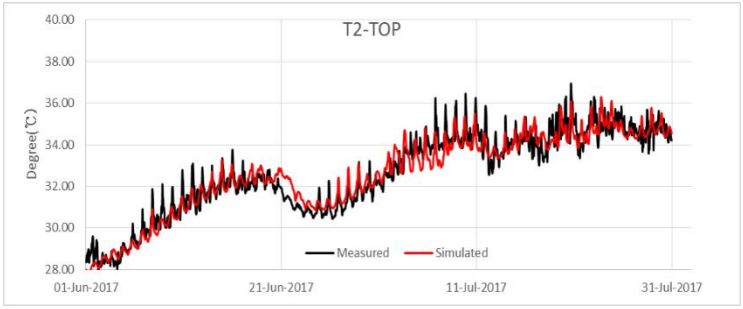


Cont., Simulation with Thermal Discharge

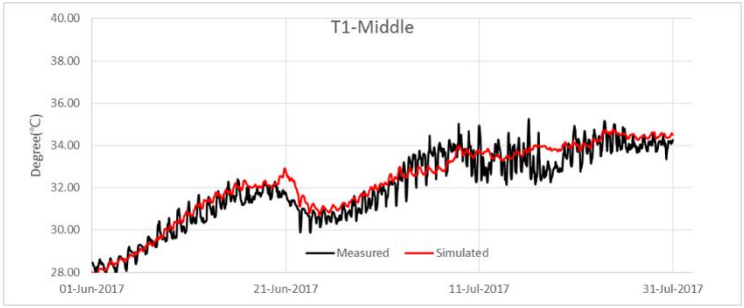
- Comparison of measured and calculated sea water temperature



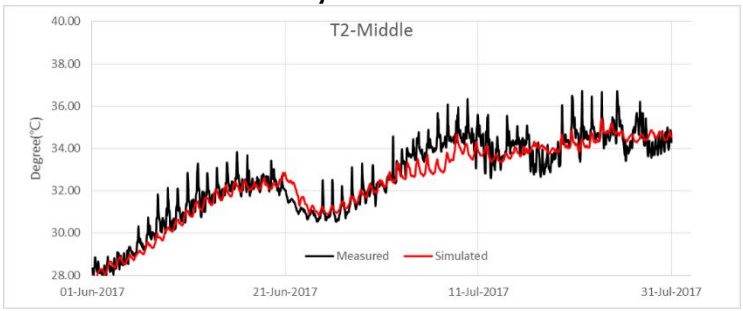
RMSE = 0.08℃ NRMSE = 1.80%



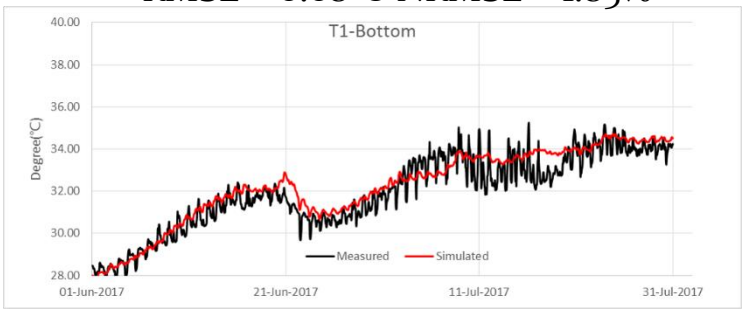
RMSE = 0.07℃ NRMSE = 1.81%



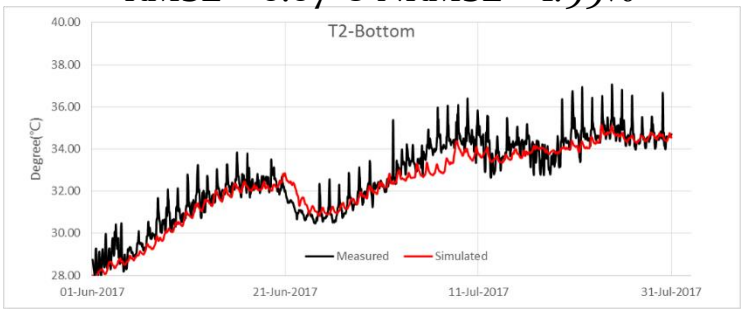
RMSE = 0.08℃ NRMSE = 1.85%



RMSE = 0.07℃ NRMSE = 1.99%



RMSE = 0.08℃ NRMSE = 2.00%



RMSE = 0.08℃ NRMSE = 2.11%

Conclusion and discussion

- It was found that the daily sea water temperature distribution around Al-Zour Site is greatly affected by the local thermal plume dispersion oscillating with the phase of tidal current.
- The regional meteorological condition also provides major contribution as a baseline condition of sea water temperature.
- Long term variation of water temperature around Al-Zour Site due to the global warming need to be considered along with the planning of the future water use in the Al-Zour industrial site in ~10 km area.