

Monitoring of gas flares with MSG active fire data – A new application of the Land SAF FRP PIXEL product

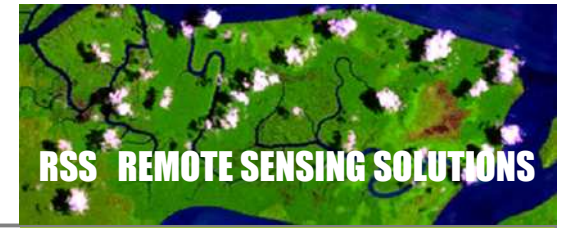
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Outline

- Introduction
- Study Environments
- Results
- Errors
- Conclusions

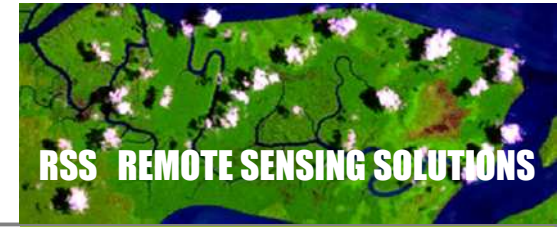


Introduction

- What is a gas flare?
 - Gas flares, or flare stacks, are associated with oil wells, gas wells, rigs, refineries, natural gas plants and landfills.
 - Commonly used practice for the disposal of waste gas in oil rich regions lacking distributive infrastructure.
 - An estimated 150 – 170 billion m³ of gas has been flared annually over the past 14 years (GGFR, Worldbank).
 - In 2008 estimated emissions from gas flaring amounted to 9% of the total CO₂ emissions of the European Union (EU-15).
 - To date, reliable and accurate data on gas flaring is hard to find and mostly based on self-reporting, independent assessments of flared gas volumes are not being carried out.

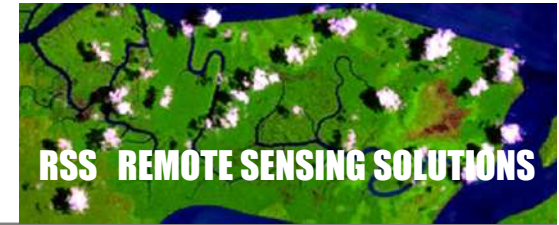


Photo Credit: Elaine Gilligan, Panoramio, Peter Roderick, Panoramio



Project objectives

- Earth Observation (EO) data has the potential to provide timely, spatially consistent, (almost) global and independent information on fires and other thermal anomalies on a regular basis.
- Project goal: enhancement of current EO service capabilities for the monitoring of gas flares by:
 - Assessing the suitability of the MSG FRP PIXEL Product for gas flare monitoring in comparison to the MODIS Active Fire Product and ESA World Fire Atlas over an extended period of time (2008-2010).

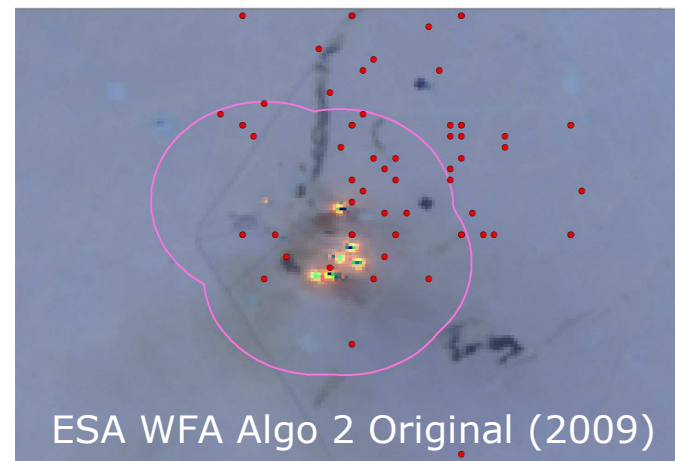
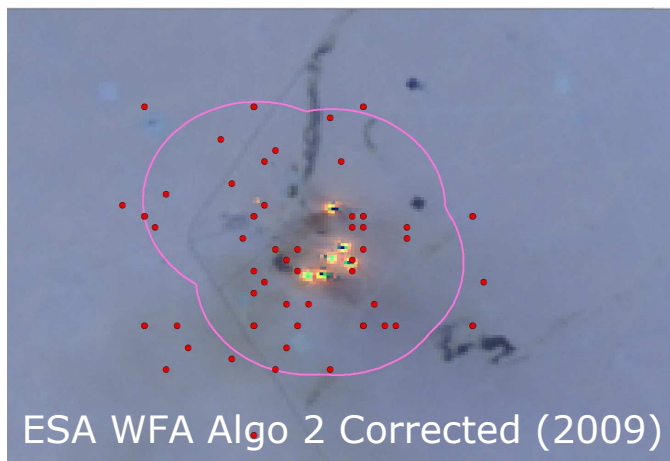
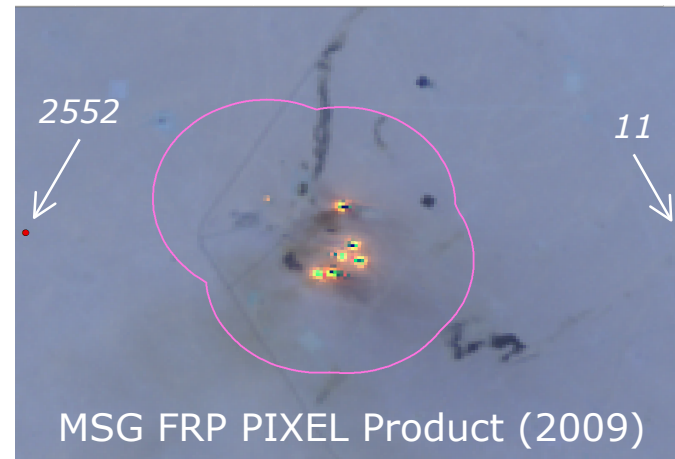
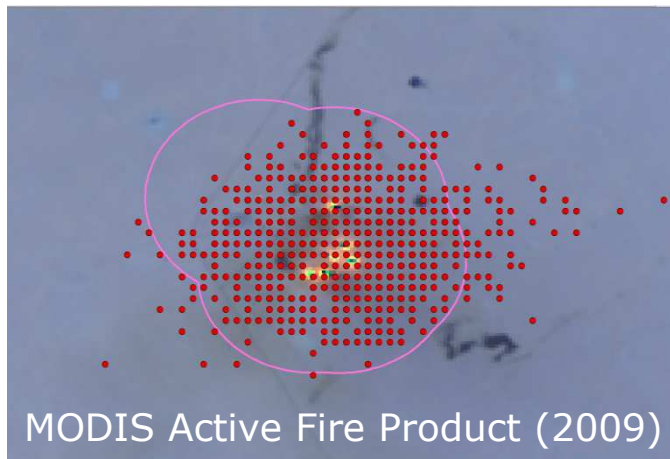


Data used

- MSG Meteosat Second Generation FRP Pixel (LSA SAF):
 - Very high temporal resolution, 1 detection/15 minutes
 - Day- & nighttime observations
 - Low spatial resolution (3km)
 - Limited coverage area
 - FRP detection
- MODIS Active Fire Product (FIRMS):
 - High temporal resolution, up to 4 detections/day
 - Day- & nighttime observations
 - Moderate spatial resolution (1km)
 - FRP detection
- ESA ATSR World Fire Atlas (ESA):
 - Moderate temporal resolution, 1 detection/3 days
 - Only nighttime observations
 - Moderate spatial resolution (1km)

Data used

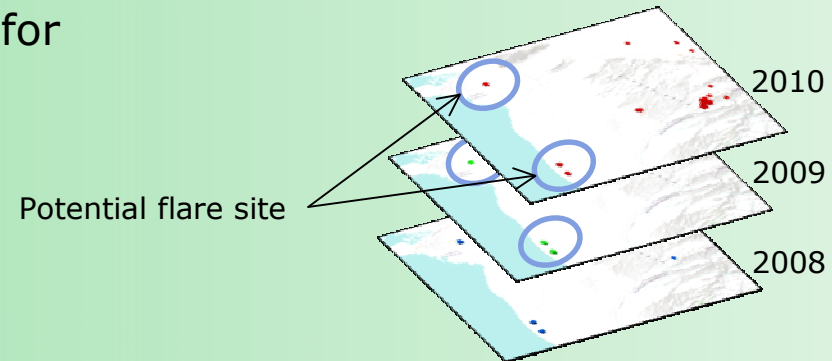
- Fire product data used – spatial representation:



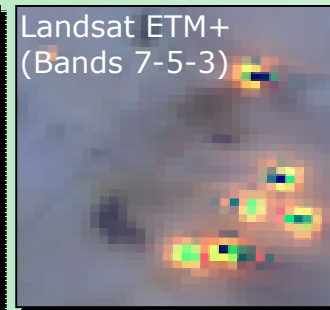
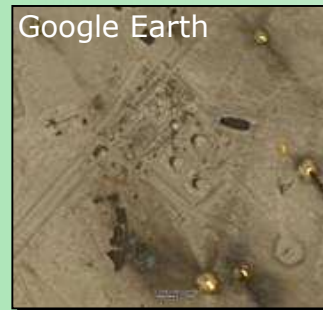
Project objectives

- General project workflow:

EO fire product screening for potential gas flare sites (ATSR, MODIS, MSG)



Reference flare screening (Landsat, Google Earth)
No in situ reference data provided



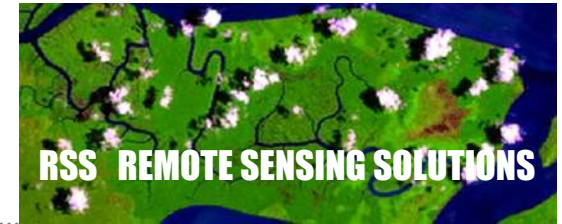
Analysis of EO fire product detection capabilities

Spatial Analyses

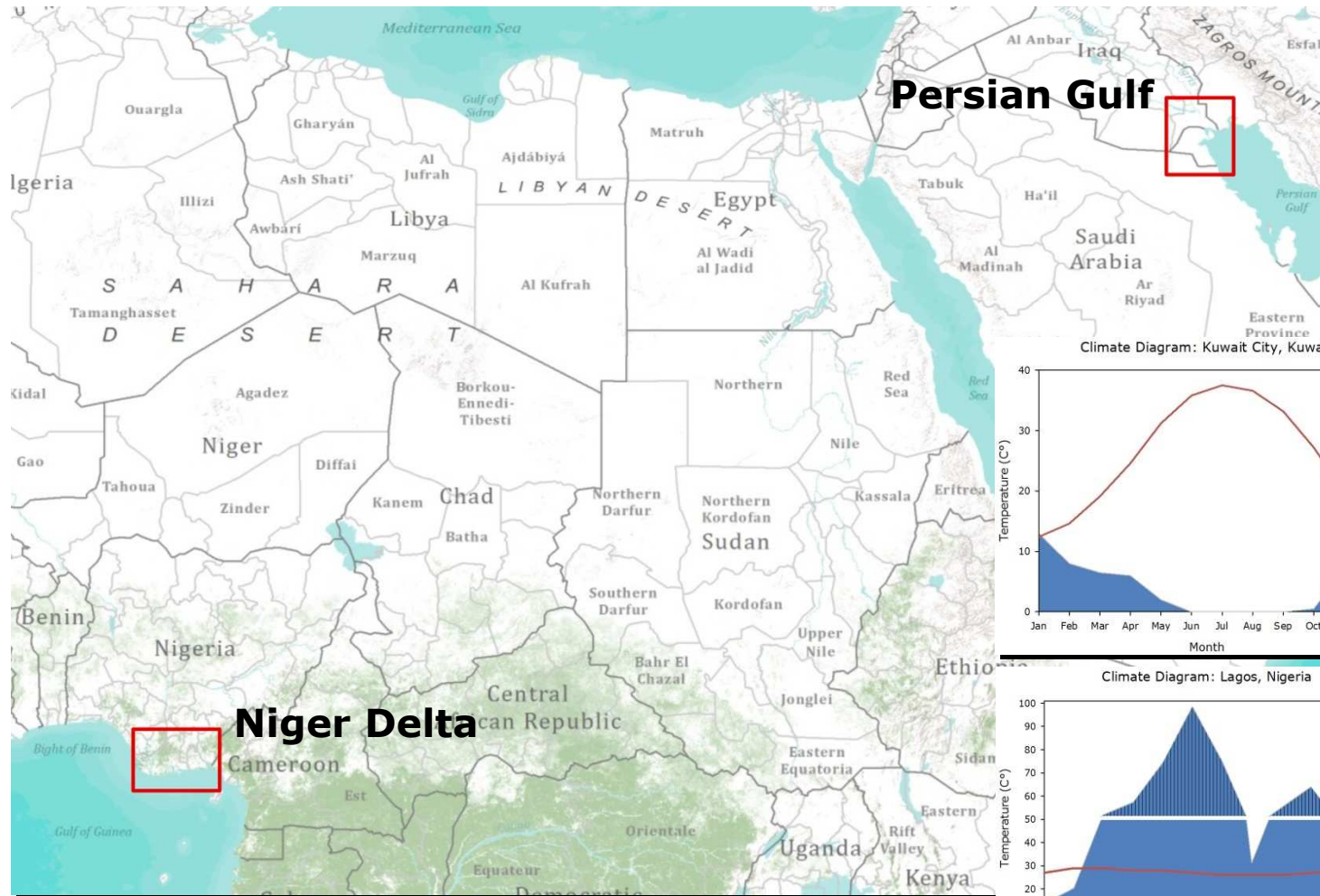
Proximity analysis

Temporal Analyses

Study area & site level
Annual, Monthly, Daily
Day- & nighttime



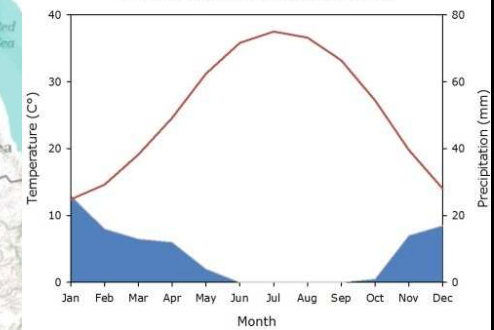
Study environments



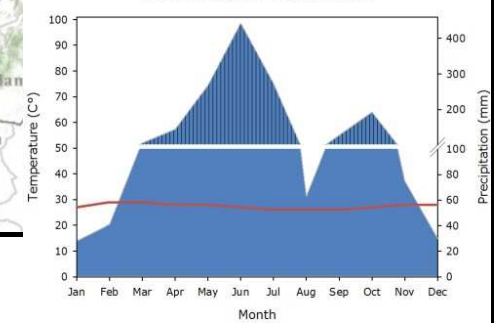
Persian Gulf

Niger Delta

Climate Diagram: Kuwait City, Kuwait

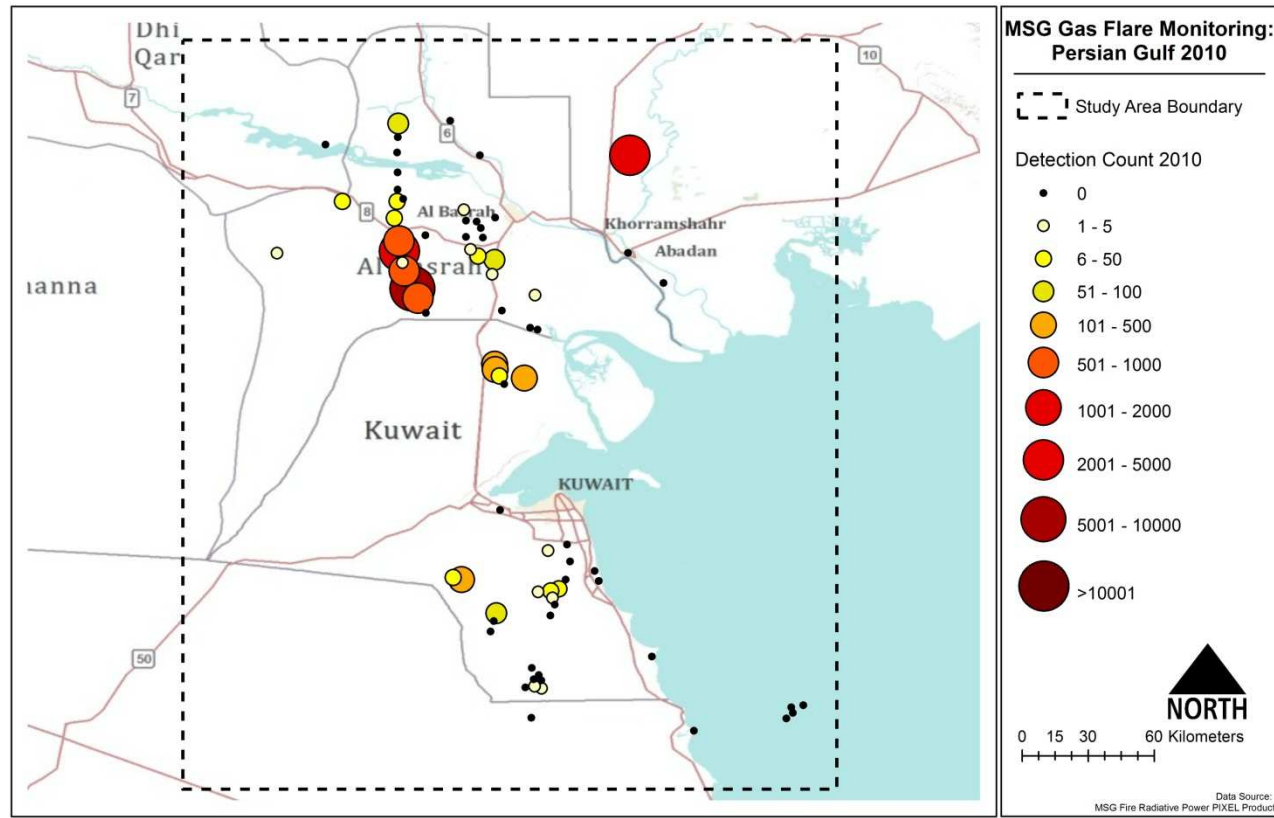


Climate Diagram: Lagos, Nigeria



Persian Gulf

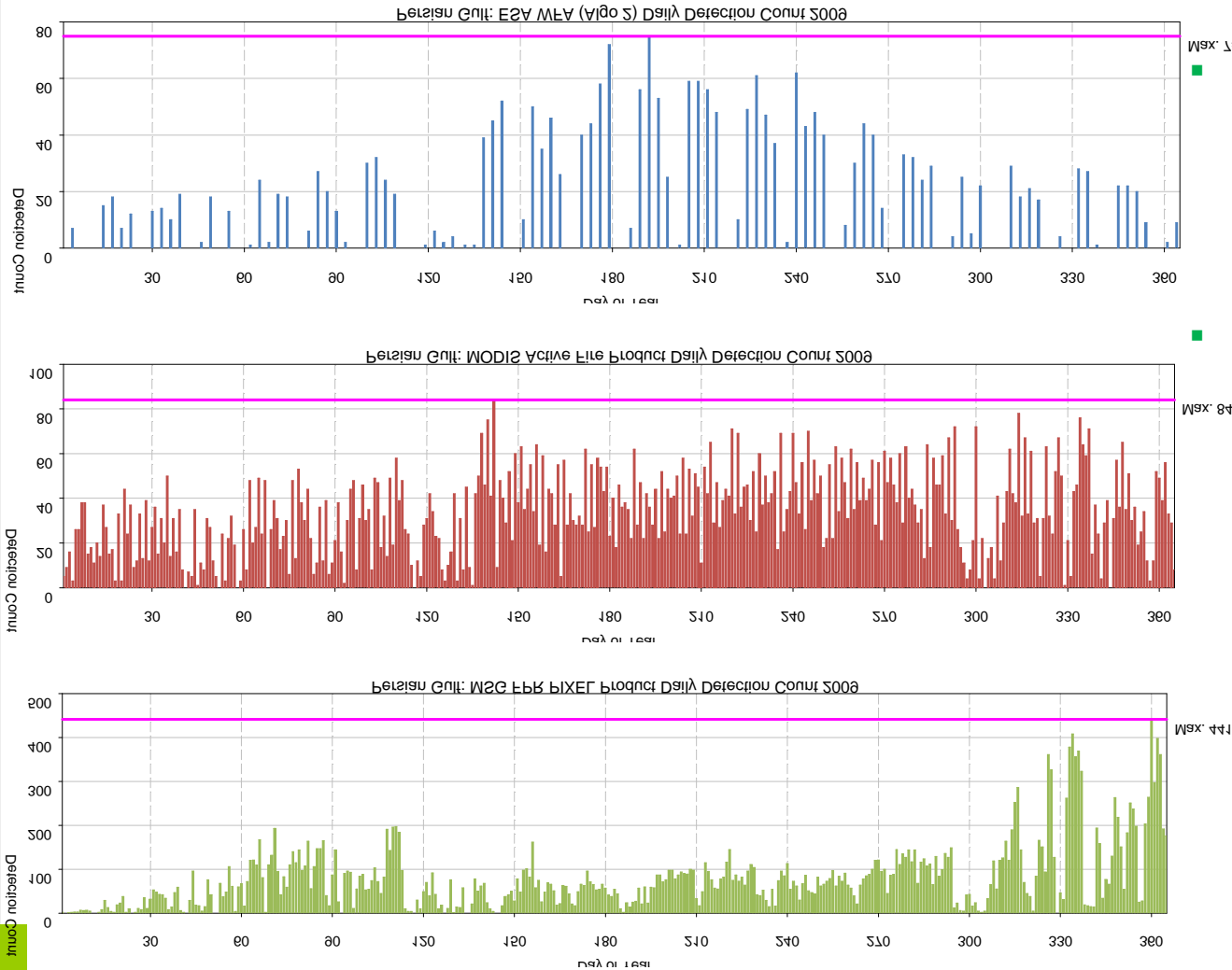
- Includes the productive oil fields of Kuwait and the oil rich Al Basrah region in southern Iraq
- A major world oil exporter with and an estimated 104 billion barrel (bbl.) (Energy Information Administration (EIA) of the U.S. Department of Energy)



73 Flare Sites:
68 onshore
5 offshore

Persian Gulf

- Fire product detection frequency in 2009

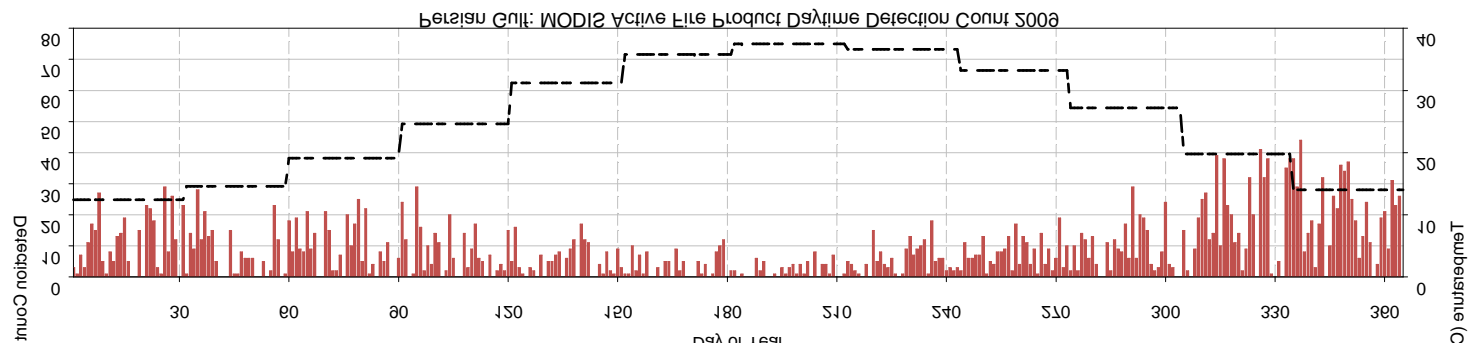


- All products successfully detected gas flare activities throughout the year

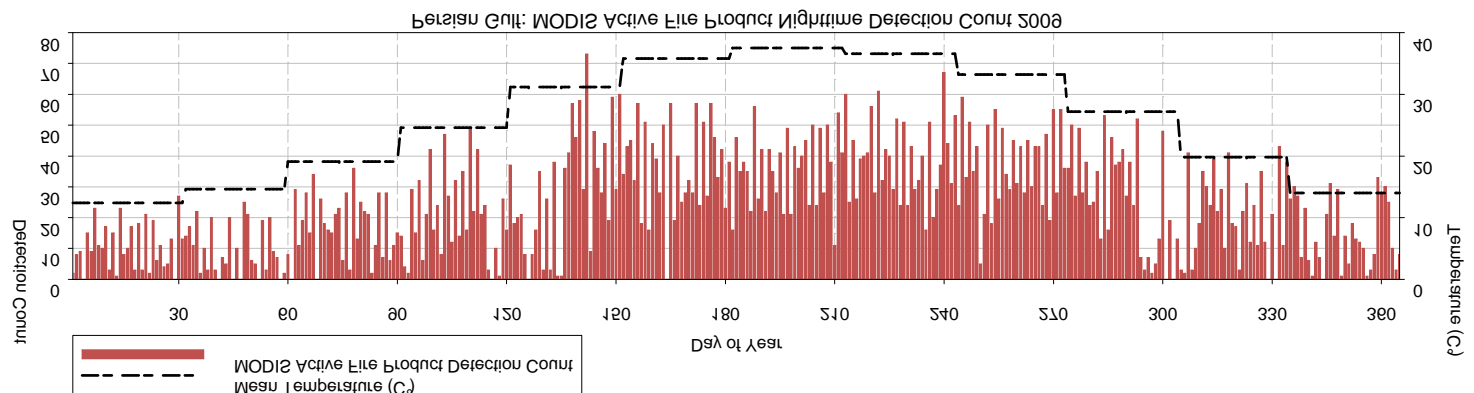
- Seasonal trend in all products due to very high summer temperatures

Persian Gulf

- MODIS seasonal detection trends:
 - Decrease in daytime detections during summer months
 - Difference between fire pixel and non-fire background pixels to small: $\Delta T (\Delta T = T_4 - T_{11}) < 10K$

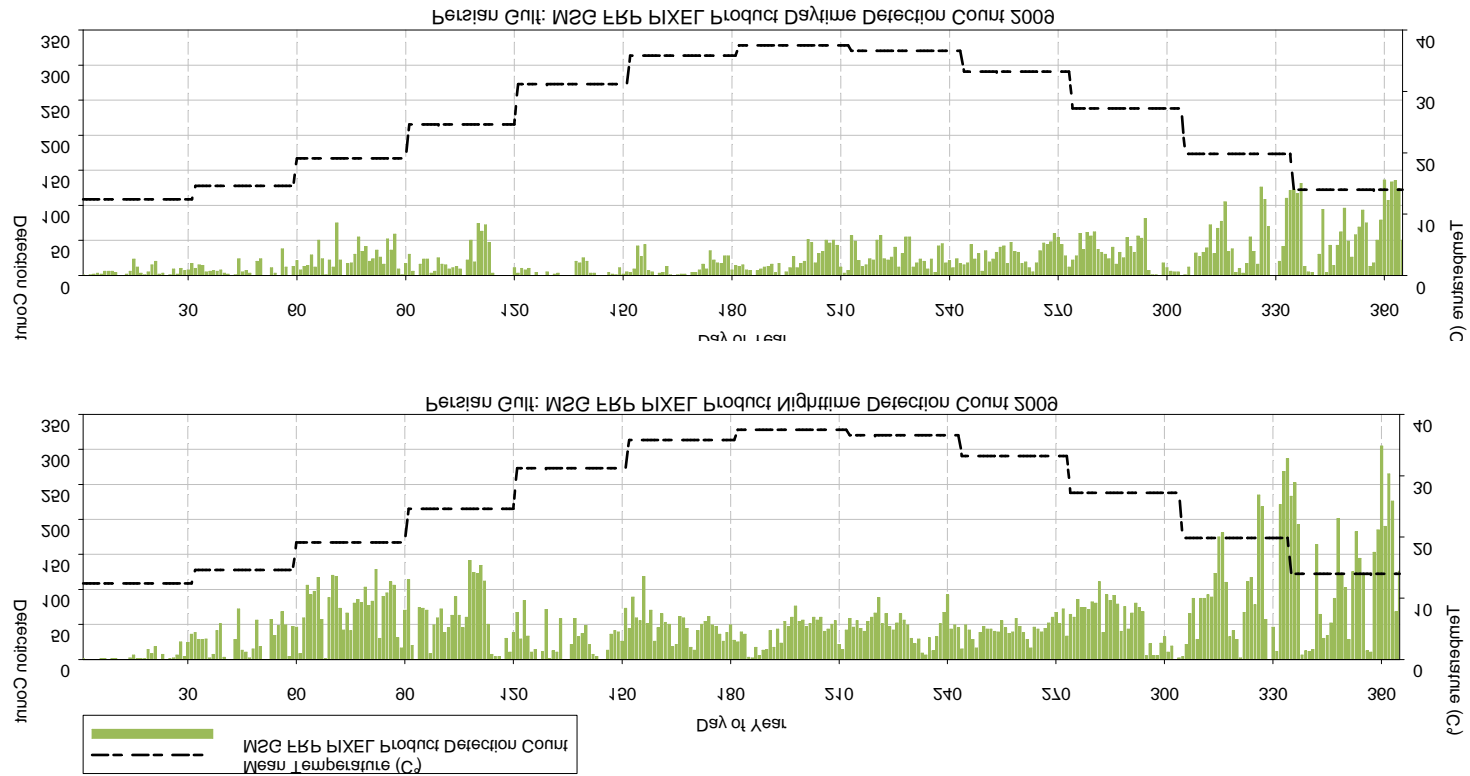


- Increase in nighttime detections during summer months
 - Due to lower brightness temperature (BT) threshold (305K)



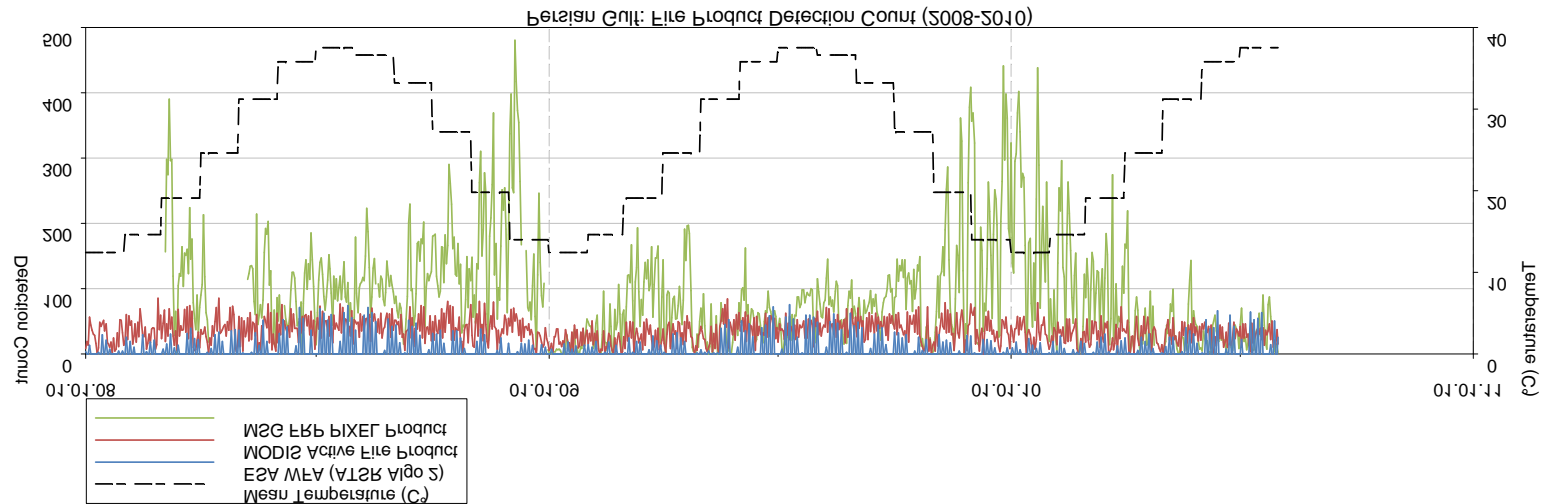
Persian Gulf

- MSG seasonal detection trends:
 - Decrease in both day- and nighttime detections during summer months
 - BT of the fire pixel is not sufficiently above the background BT



Persian Gulf

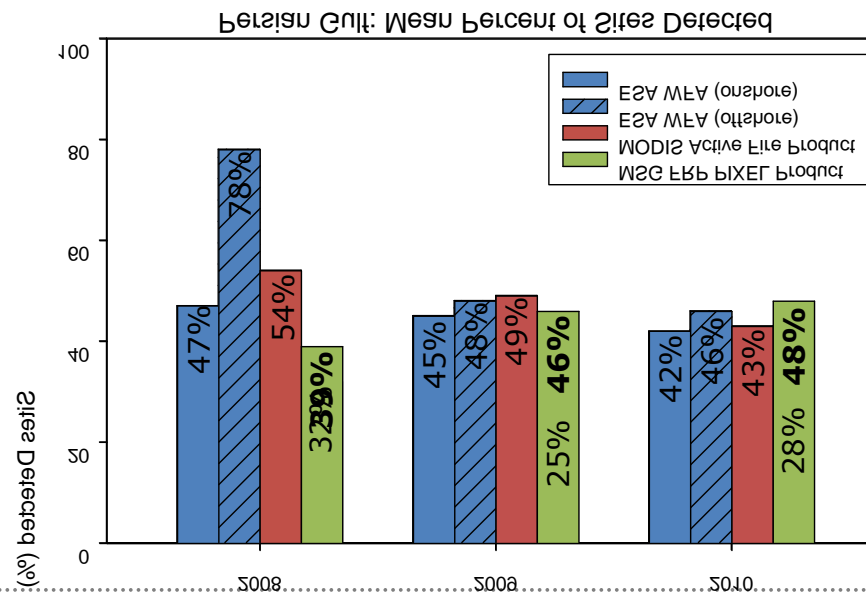
- The seasonal trends of all fire products were present during entire study period (2008-2010):





Persian Gulf

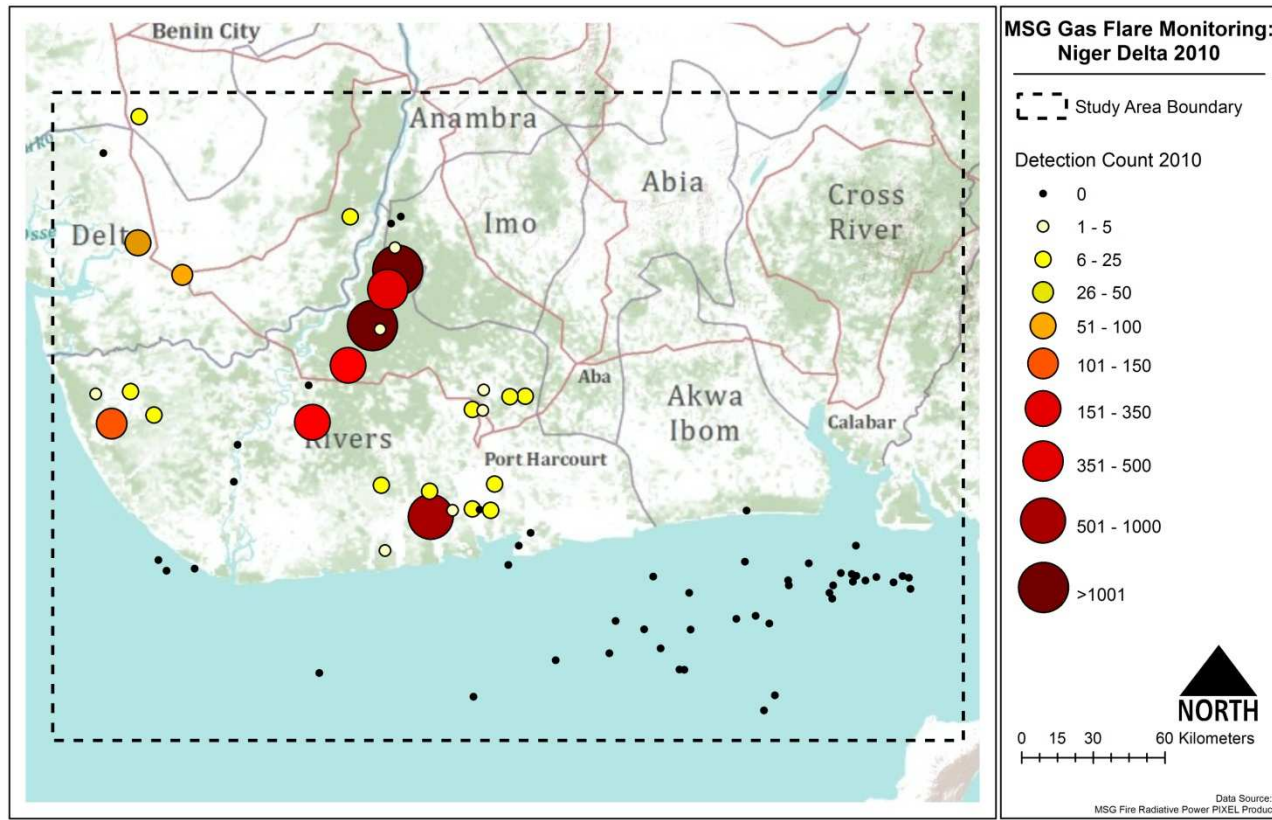
- MODIS and ESA WFA successfully identified more gas flare facilities during the study period than MSG
 - Spatial distribution of facilities limited MSG – numerous facilities within 3km of each other
 - When accounting for the difference in spatial resolution (flare buffer increases from 1 to 3km), MSG performance equaled and in cases surpassed that of MODIS and ESA WFA





Niger Delta

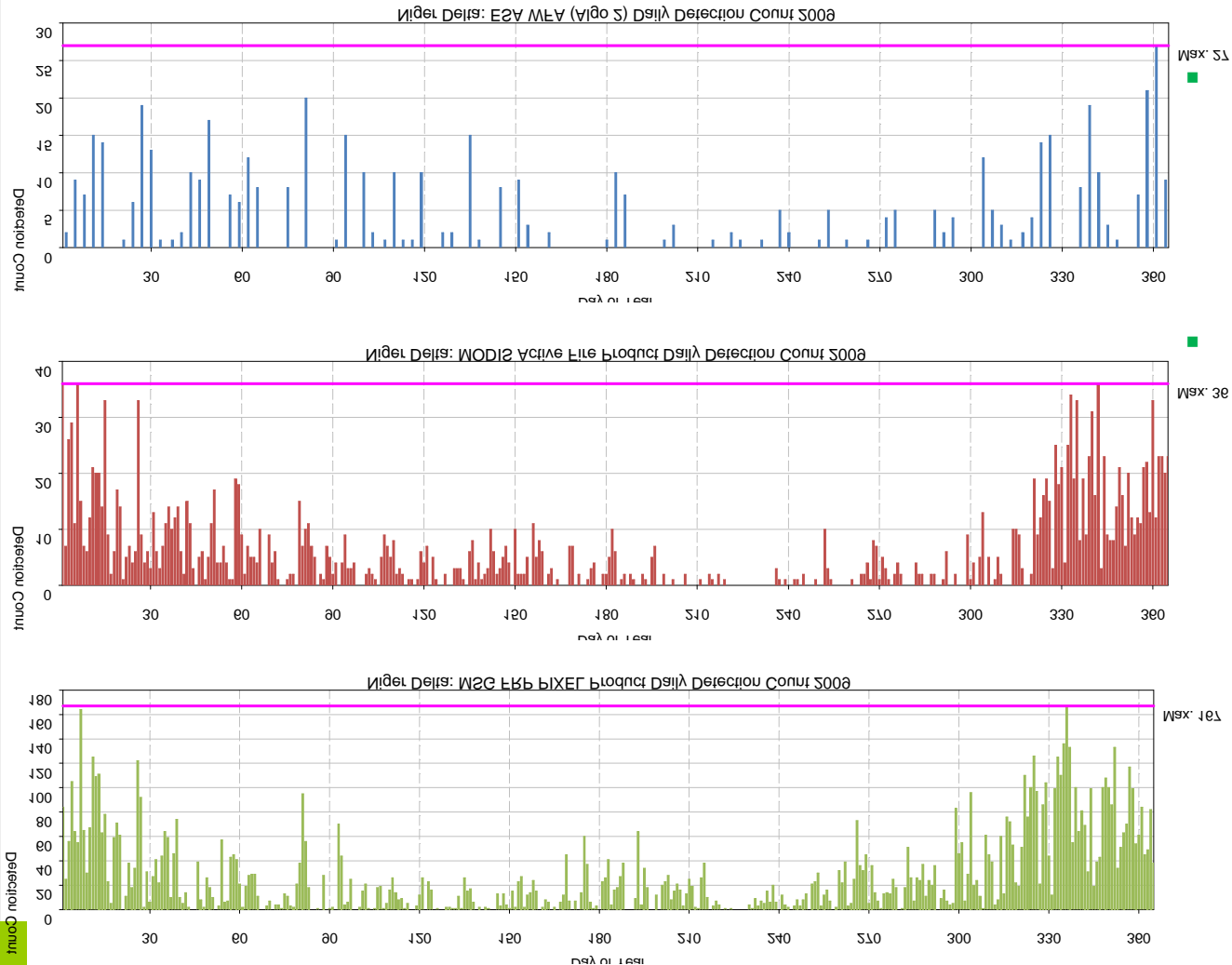
- World's second most active gas flaring country according to the Global Gas Flaring Reduction (GGFR). The Niger Delta is rich in oil resources and characterized by a network of oil production infrastructure stretching up the river channels. Nigeria also has a large amount of offshore oil activity concentrated within 80 km of the coastline.



77 Flare Sites:
38 onshore
39 offshore

Niger Delta

- Fire product detection frequency in 2009



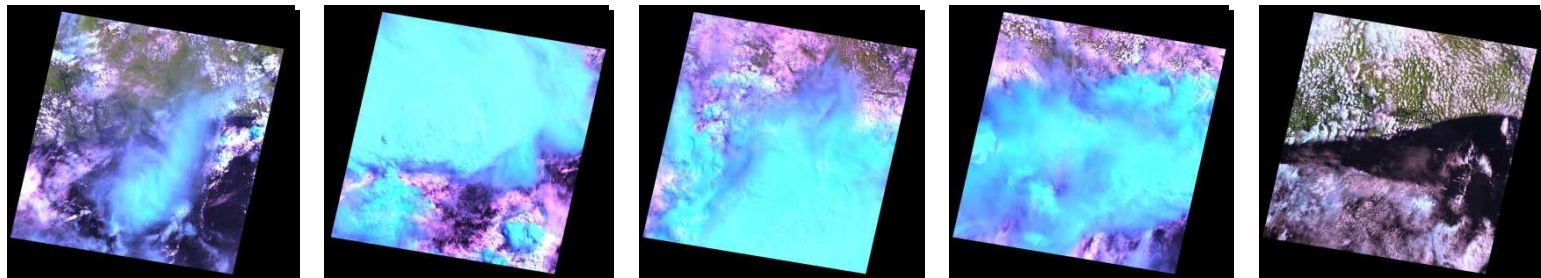
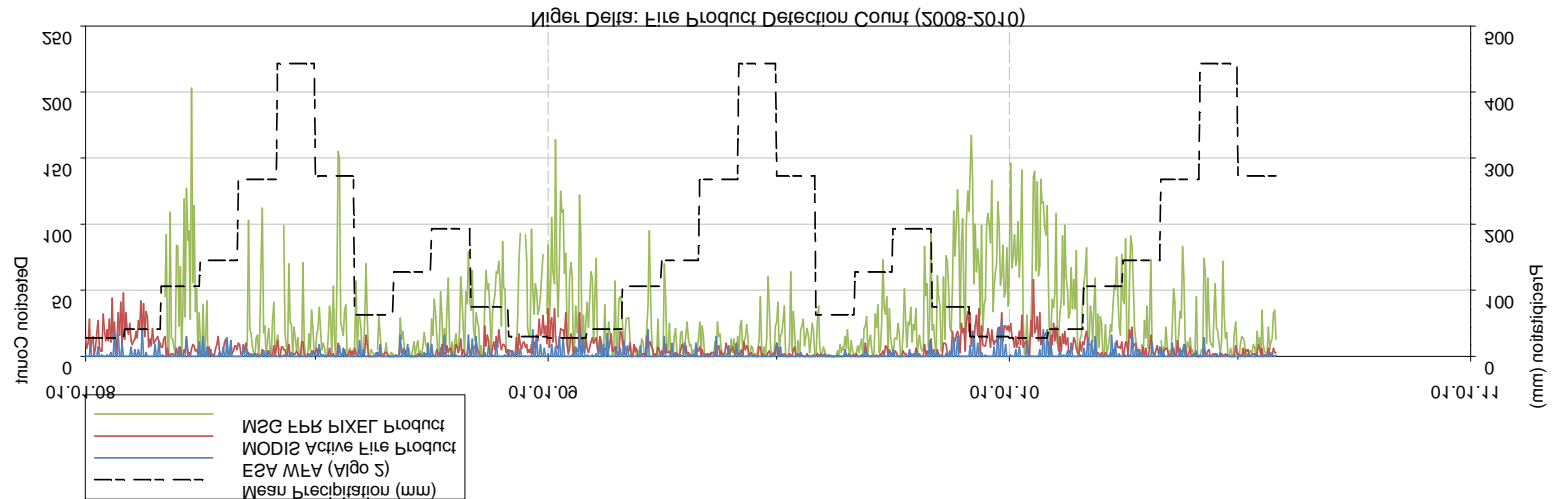
- All products successfully detected gas flare activities throughout the year

- Seasonal trend in all products due to well defined wet & dry seasons



Niger Delta

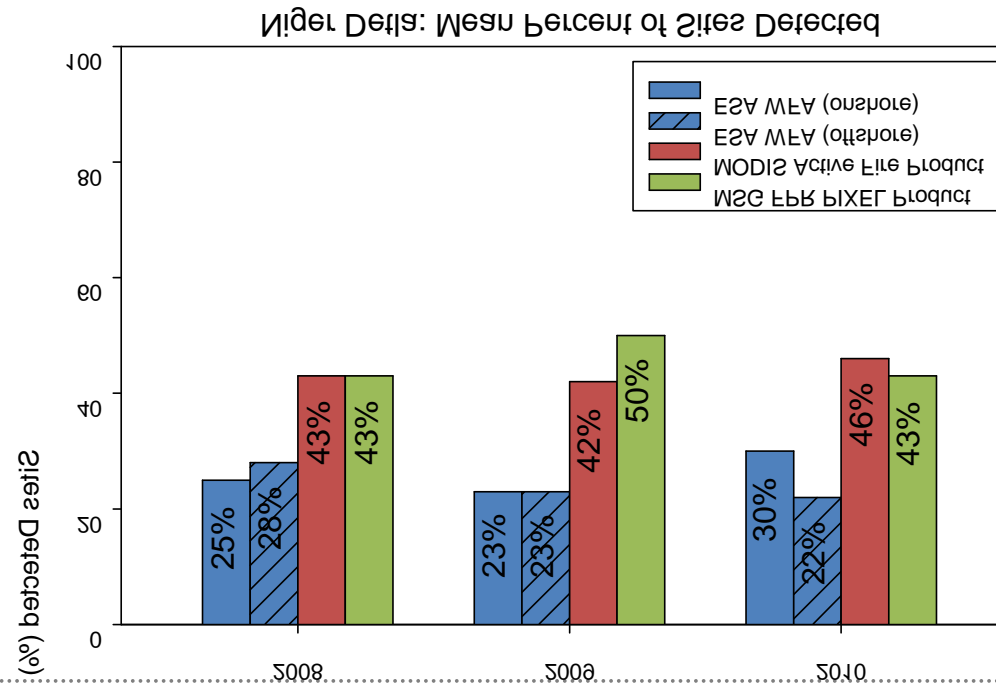
- The seasonal trends of all fire products were present during entire study period (2008-2010):
 - Number of detections decreased significantly in wet season due to increased cloud cover

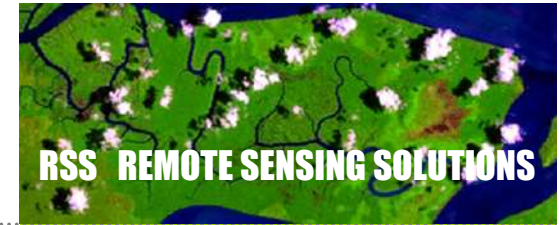




Niger Delta

- MSG and MODIS captured significantly more gas flare site during the study period
 - Higher temporal resolution is crucial in regions with increased cloud cover
 - MSG has great advantages in such conditions





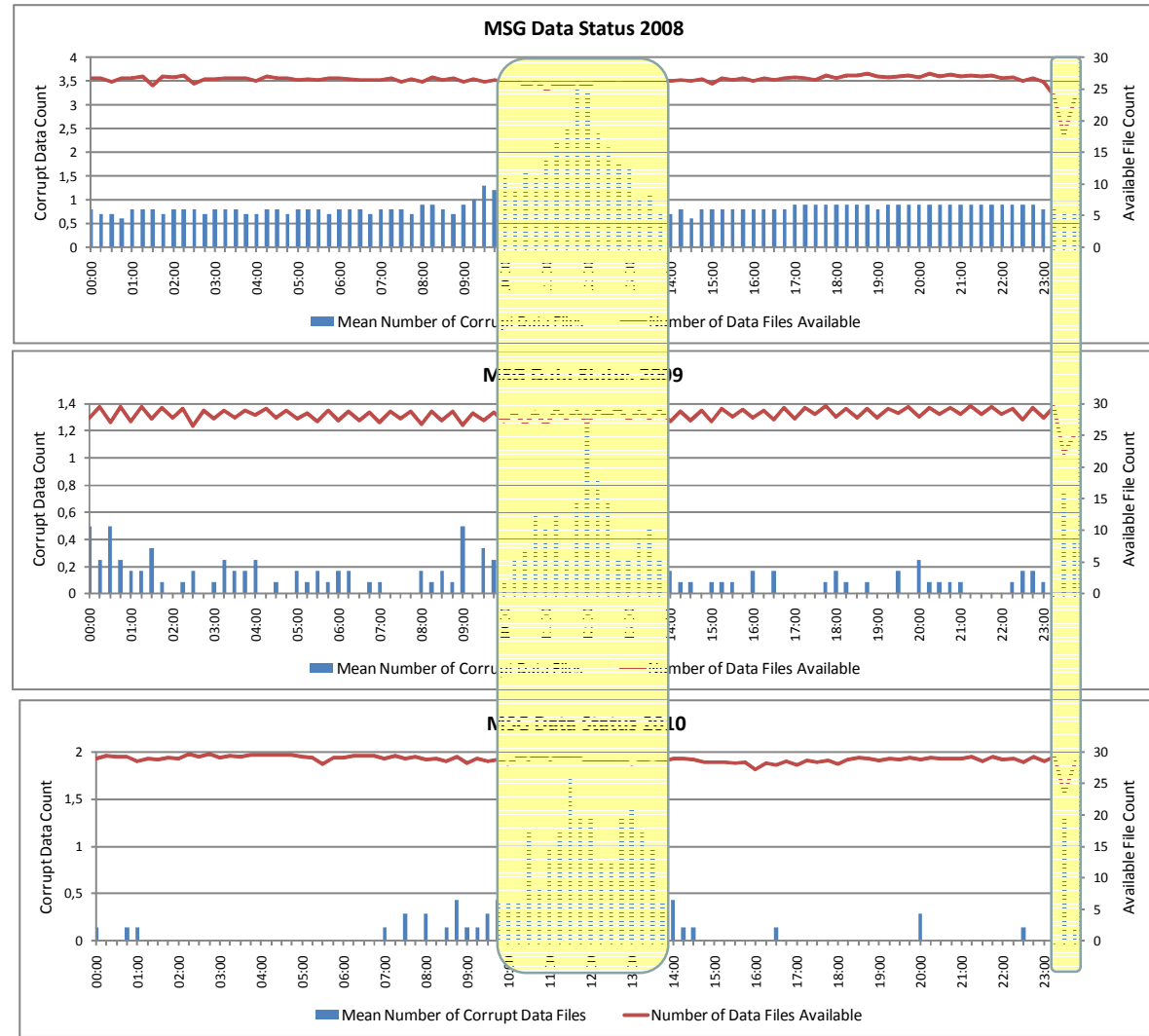
Potential Errors

- Missing data/ sensor errors
 - MODIS – 0% (during study period)
 - ESA WFA – NA (13.5% 2005-2008)
 - MSG (N. Africa) – 10.1% (04.03.08-31.07.10)
- Algorithm conditions
 - Cloud mask thresholds, water masks
- Background brightness temperatures
 - Extreme temperature conditions
- Atmospheric conditions
 - Cloud cover
- Off-nadir inaccuracies
 - Increased pixel size
- Reference flare errors
 - Gas flares omitted
 - Incorrectly identified

Potential Errors

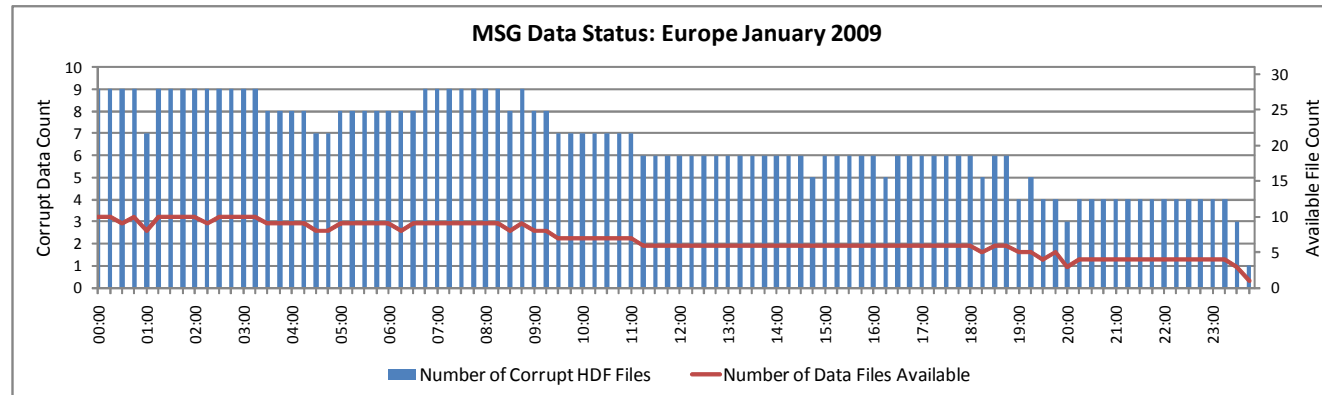
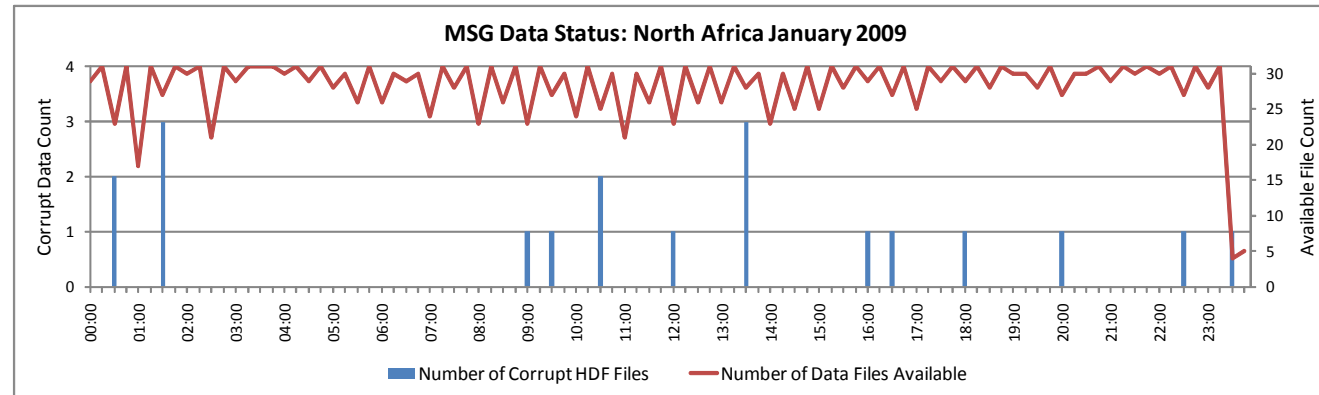
- Patterns in missing/erroneous MSG data:

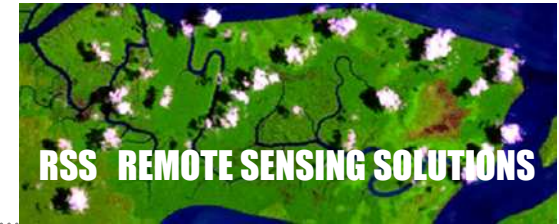
- The 23:30 problem – datasets not available?
- Mid-day empty HDFs?



Potential Errors

- Differences in MSG datasets:
 - Significant difference in data quality and availability between North Africa and Europe datasets
 - How can the same image (file) be so different?





Conclusions

- All three fire products have advantages and disadvantages:

MSG FRP PIXEL Product	
Advantages	Disadvantages
<ul style="list-style-type: none"> very high temporal resolution FRP value 	<ul style="list-style-type: none"> low spatial resolution water mask – no offshore detections possible limited sensor coverage difficult data format (HDF)
MODIS Active Fire Product	
<ul style="list-style-type: none"> high temporal resolution moderate spatial resolution FRP value global coverage 	<ul style="list-style-type: none"> water mask – no offshore detections possible limited detections in extreme temperature conditions limiting cloud mask thresholds
ESA WFA (Algo 2)	
<ul style="list-style-type: none"> moderate spatial resolution global coverage no water mask – offshore detections possible 	<ul style="list-style-type: none"> low temporal resolution limited detections in extreme temperature conditions no FRP value



Conclusions

- Despite limitations, MSG shows excellent potential for gas flare monitoring
 - Performed well in both study areas (desert & tropical conditions)
 - Performance on par with MODIS
 - Very high temporal resolution advantageous in areas with cloud cover and provides detailed monitoring capabilities
- Scale and location of monitoring are key issues in determining product choice
- MSG data distribution problems must be resolved in order to reliably use the product for gas flare monitoring

