NPA Exploration Services 2019

Mike King – NPA Satellite Mapping

cgg.com

NPA's History

1972   2008   2013

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Who are NPA?

- **Satellite mapping**
  - Geological mapping
    - Oil and gas exploration
    - Mineral exploration
  - Seep mapping
  - Satellite imagery & DEM
  - InSAR

- **Markets**
  - **Oil and gas**
  - Mining
  - Infrastructure and civil engineering
  - Environmental and pollution monitoring

- **Right imagery for the job**
  - Impartial advice spanning over 65 satellite missions (Optical, SAR, DEM)
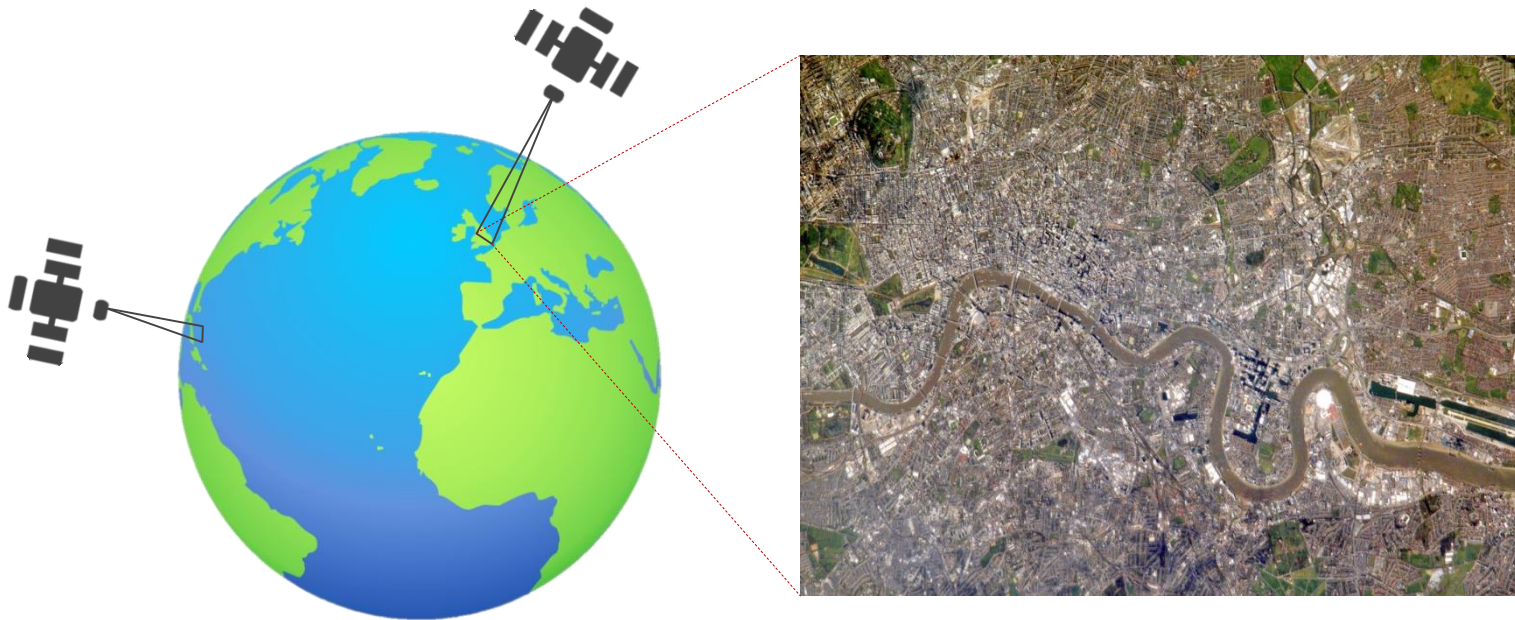 - Archive data, custom tasking and specialist processing

© CGG | NPA Satellite Mapping
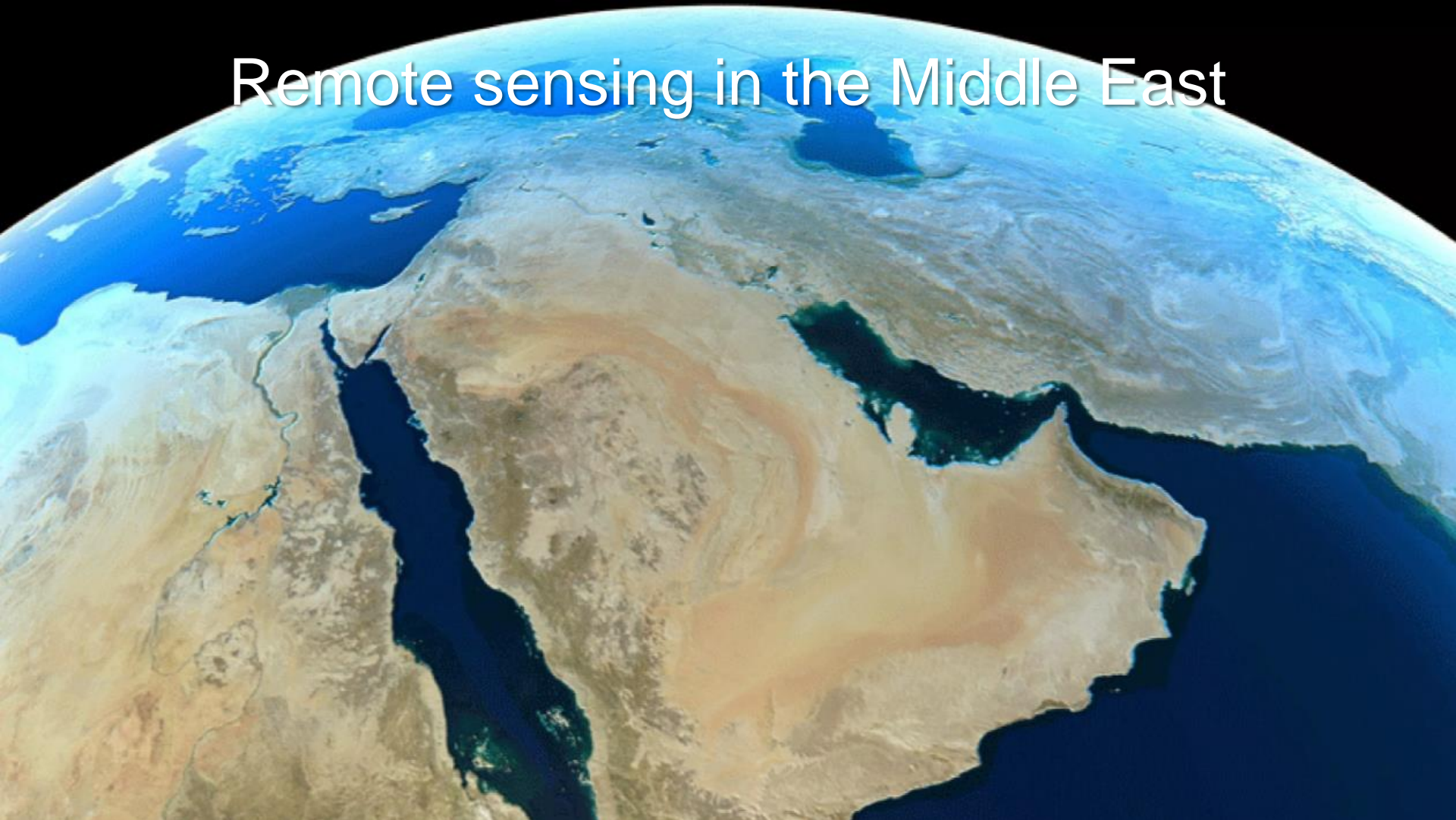
Remote Sensing
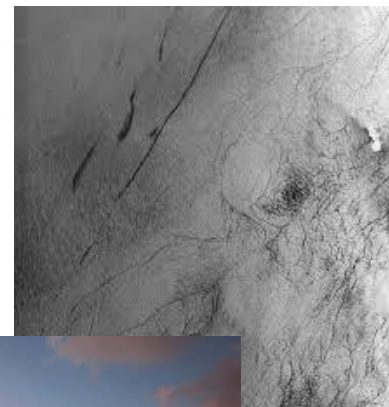
© CGG | NPA Satellite Mapping

Satellite Remote Sensing

The science of extracting information remotely from an object or area through the analysis of data acquired by satellite

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Remote sensing in the Middle East

What can RS offer in the Middle East?

Onshore

- **Geological mapping**

- **Seepage detection (ish)**

- Monitoring – INSAR, infrastructure

- Survey planning
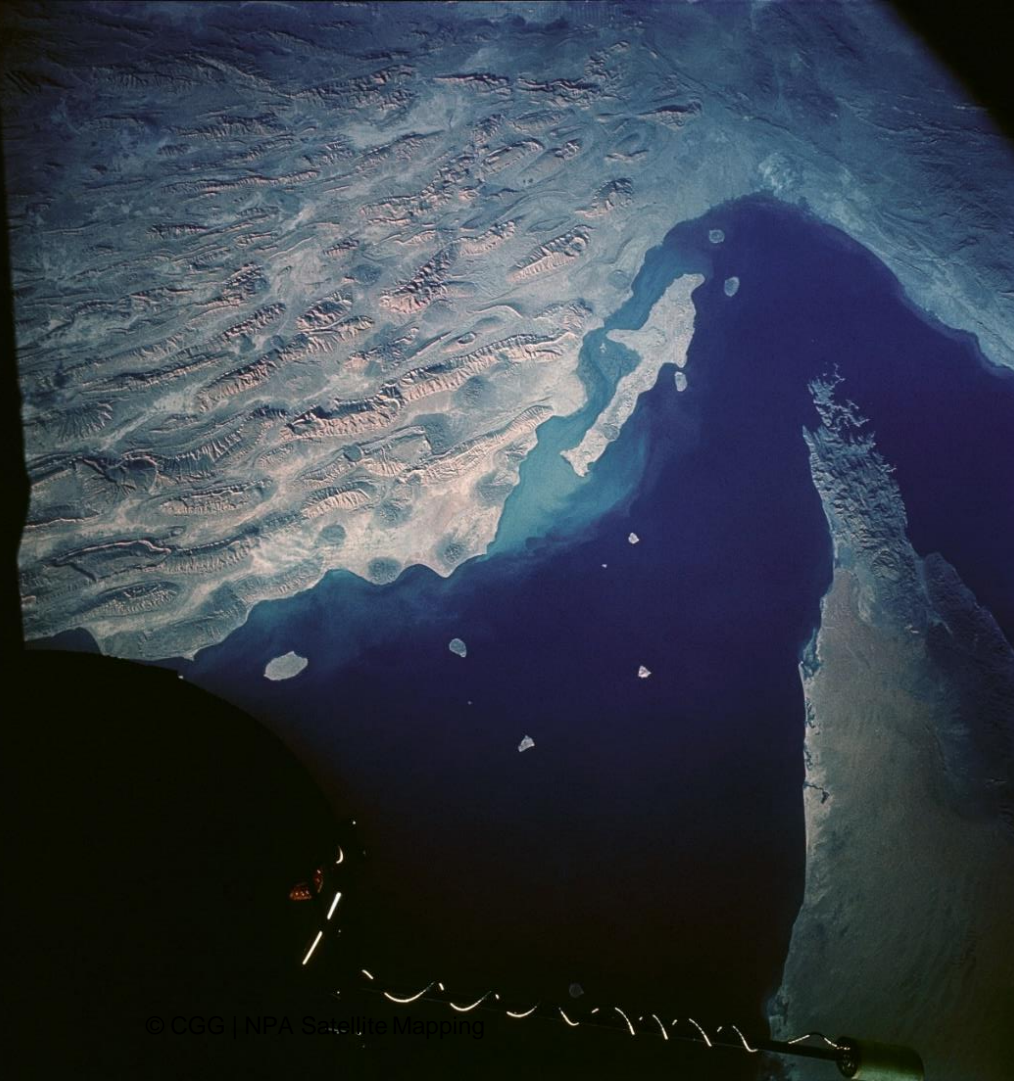
- Geohazards

Offshore

- **Seepage detection**

- Gravity (regional), Magnetics (regional), Bathymetry (regional & shallow)

- Monitoring – Pollution (benchmarking and monitoring)

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Onshore

Satellite remote sensing in the middle east – 1966!

Left - Gemini 12 view of Fars, Oman and Qishm Island

Above - Buzz Aldrin performing spacewalk
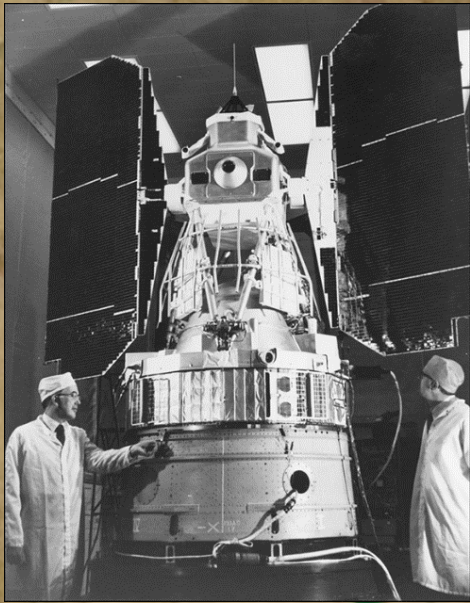*13 November 1966*

Remote sensing & the Middle East

Ideal location:

- Arid

- Limited vegetation

- Clouds less of an issue, large archives of imagery

- Good geological exposure

- Topography controlled by structure

- Recent tectonic development (Zagros, Taurys etc.)

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- Landsat 1 (1972)
- Optical (6 Bands)
- 80m resolution
- $5.9 billion! (2018)
- Landsat 8 $858 Million

- Landsat 4 (1982)
- Optical (6 Bands)
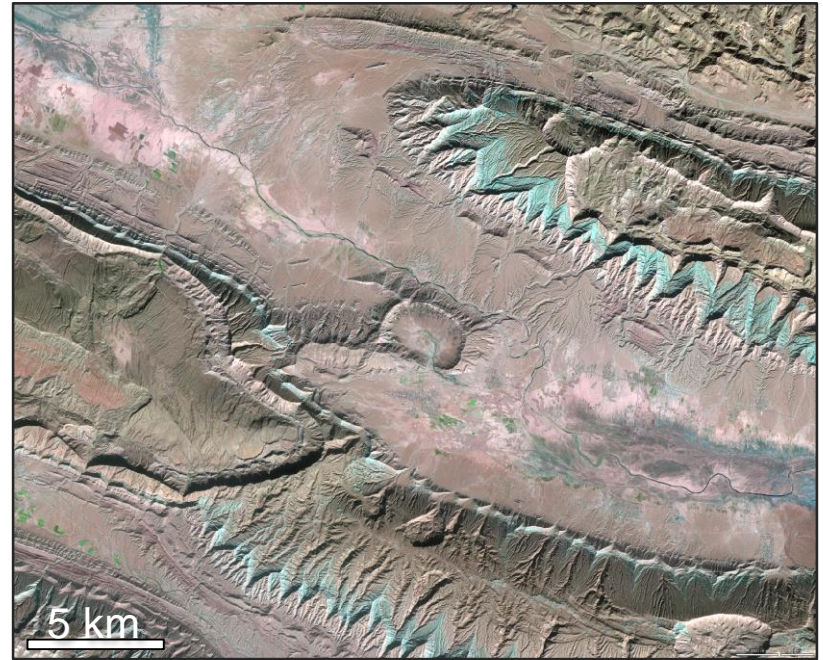- 30m resolution

Geological mapping

© CGG | NPA Satellite Mapping

Data selection - Summer vs Autumn

© CGG | NPA Satellite Mapping
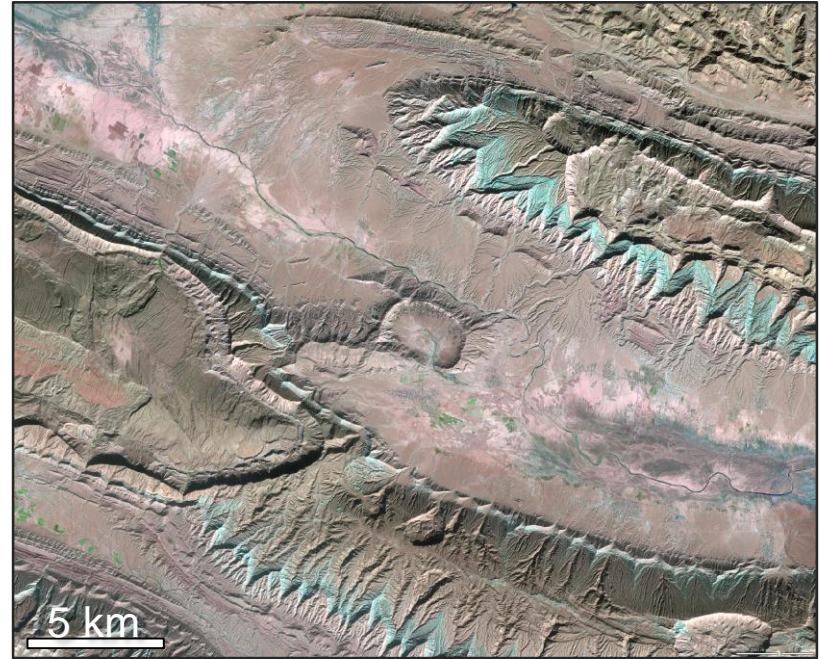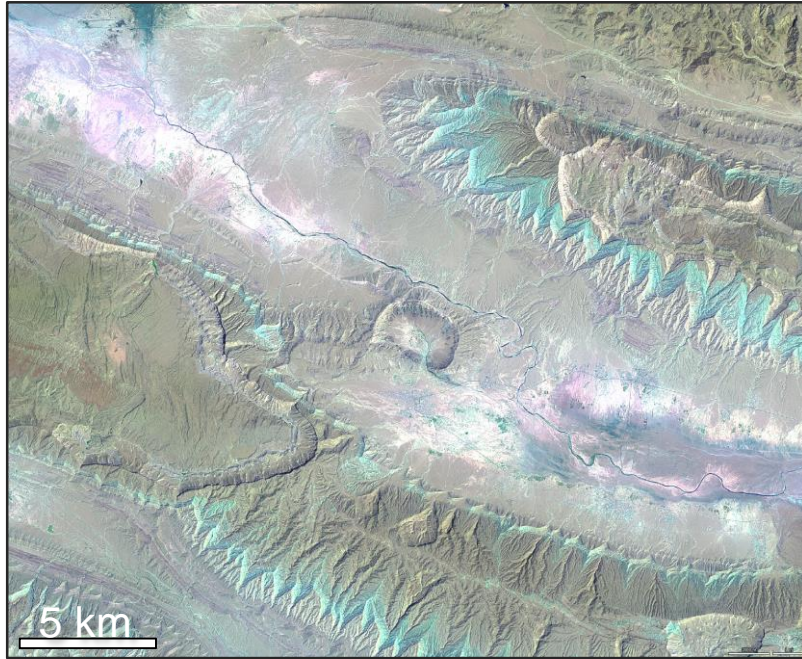
Data preparation - Real colour vs false colour

© CGG | NPA Satellite Mapping

Sentinel-2 (12-8-3 band combination)
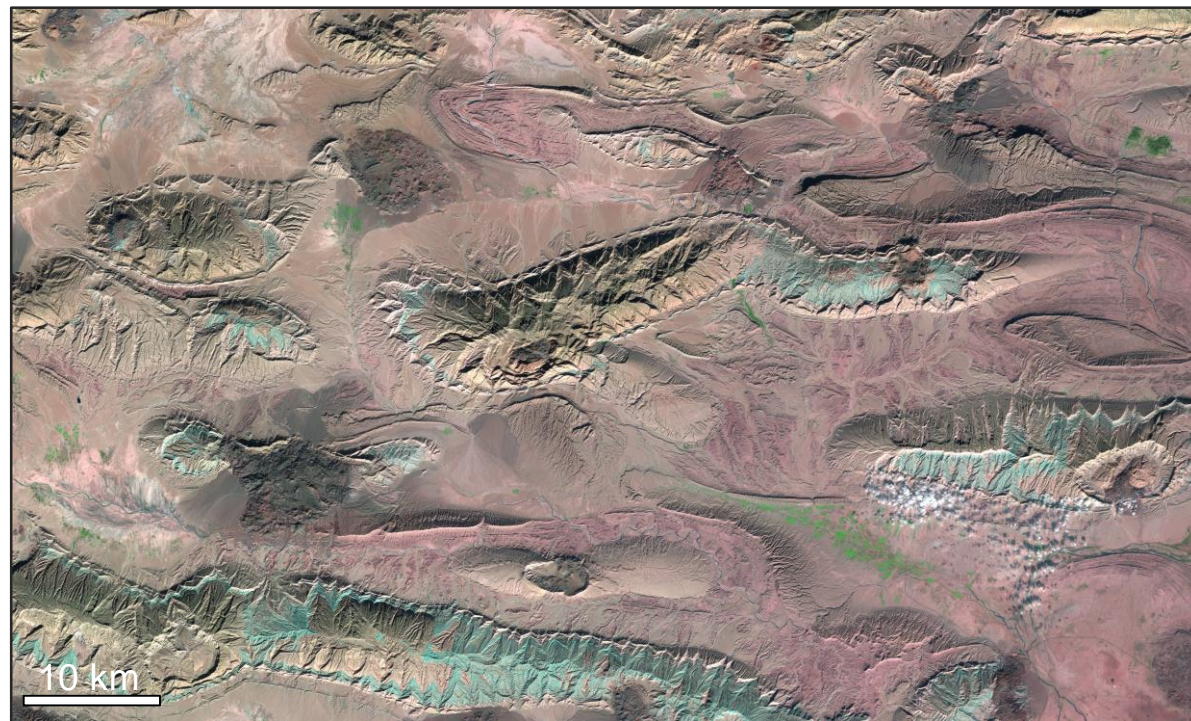
Remote Sensing Signature

Quaternary
Bakhtiari (Plio-Pleistocene)
Agha Jari (U. Miocene)
Mishan (M. Miocene)
Guri (M. Miocene)
Gascharan (L.-M. Miocene)
Asmari (Olig.-L. Miocene)
Pabdeh-Gurpi (U. Cret-Olig)
Bangestan Gp (U. Cretaceous)
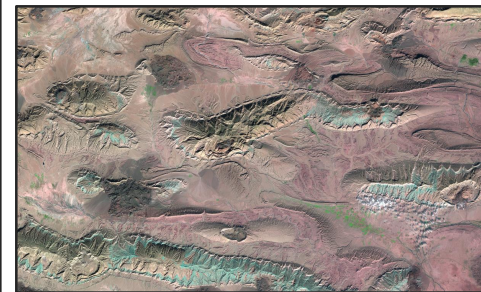Khami Gp (L. Cretaceous)
Hormuz salt (Precambrian)

10 km

© CGG | NPA Satellite Mapping

Digital Elevation Model (SRTM-1) 30 m resolution

10 km

Sentinel-2

© CGG | NPA Satellite Mapping
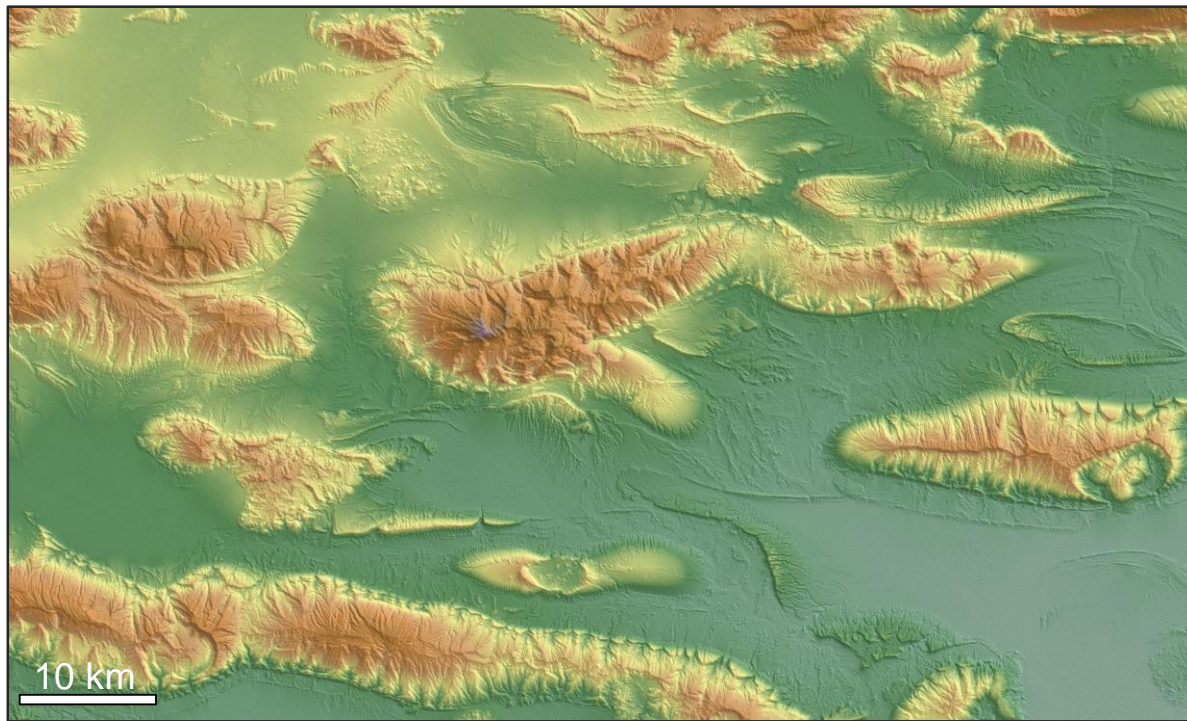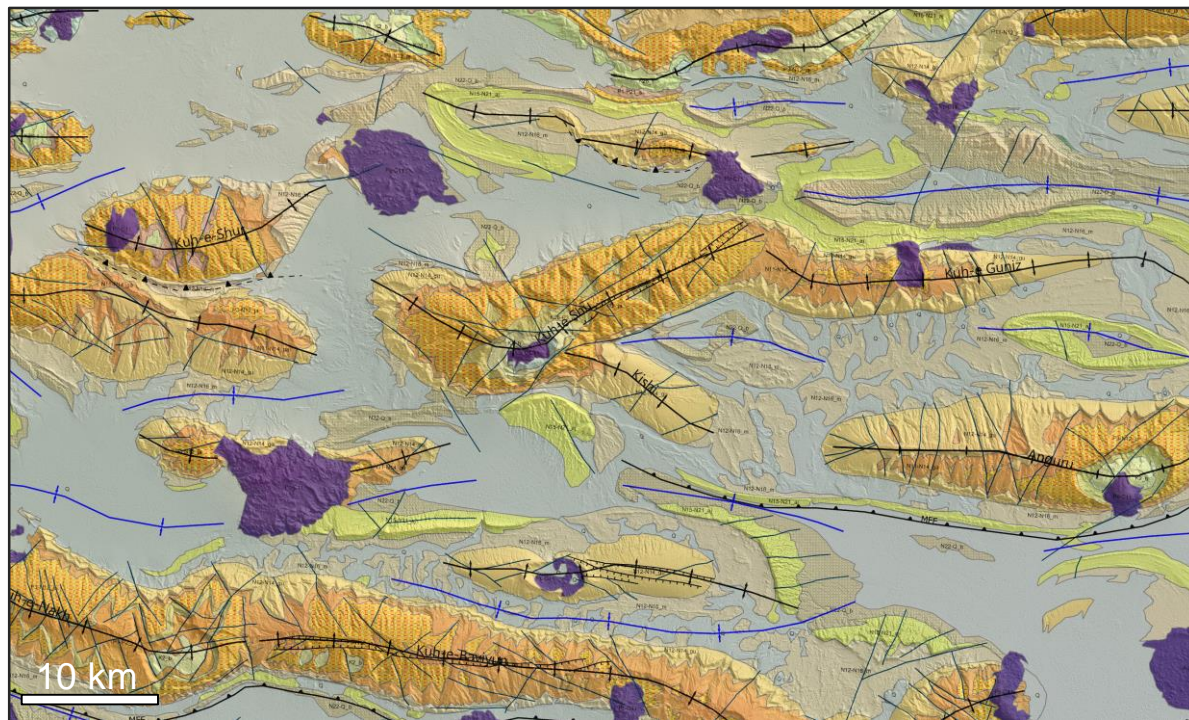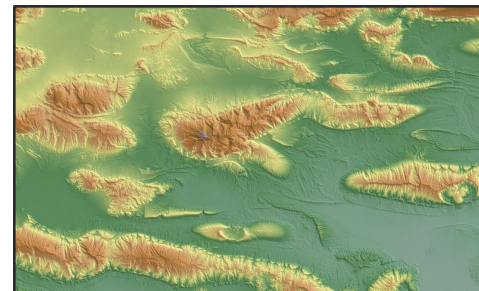
1:200,000 Geological Map

SRTM-1 DEM

10 km

© CGG | NPA Satellite Mapping

Now – Open access DEMs

SRTM 90m

SRTM 30m

AW3D30
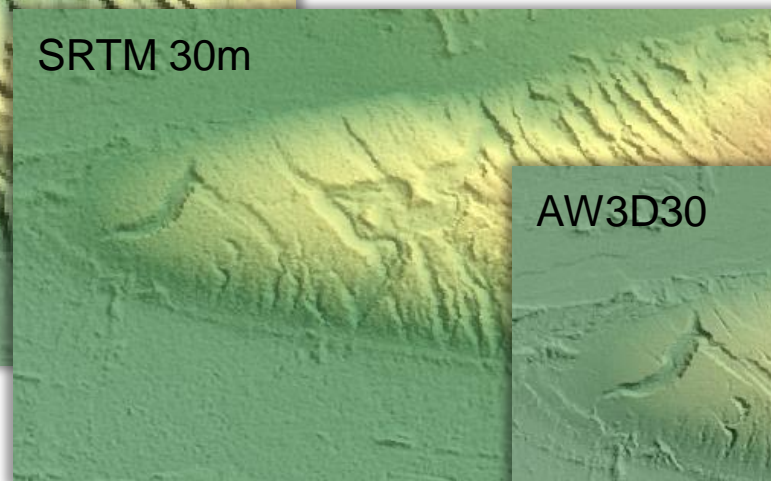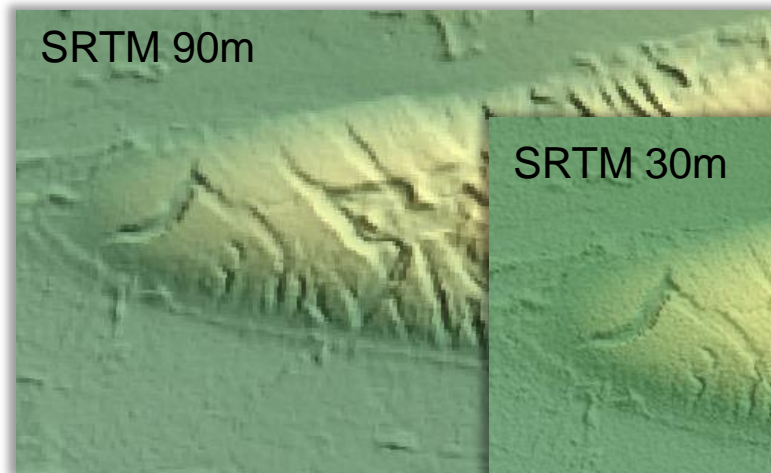
Plus global high res models at a fraction
of the cost now available!

© CGG | NPA Satellite Mapping

Structural modelling: dip extraction

© CGG | NPA Satellite Mapping
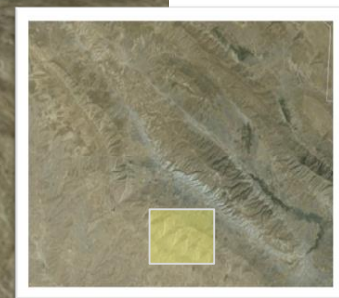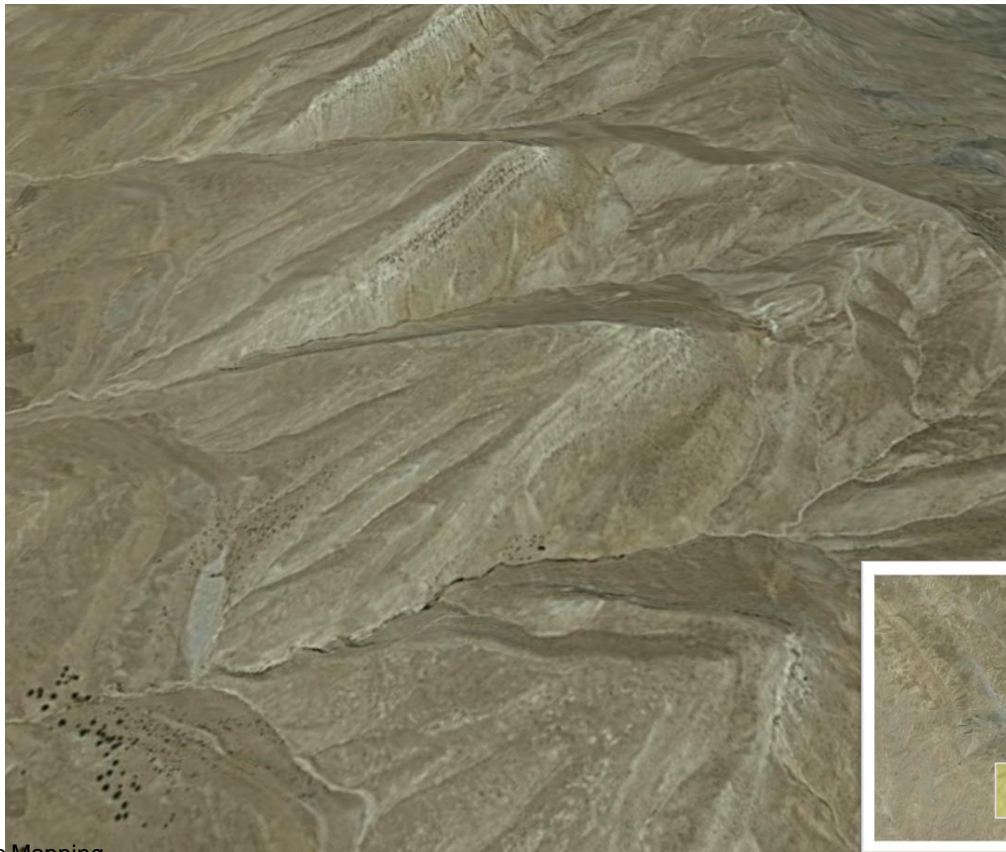
Dip angle and azimuth extraction from DEM

© CGG | NPA Satellite Mapping
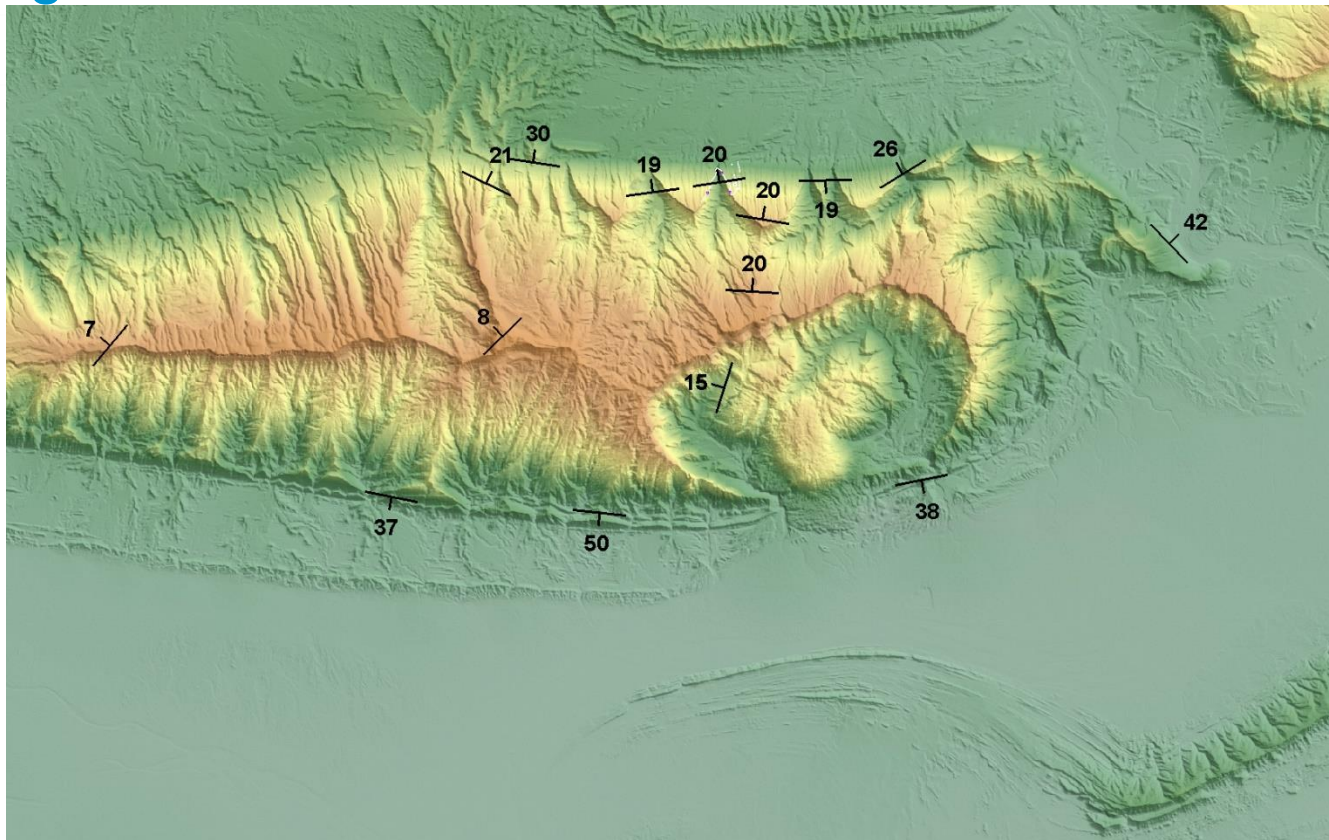
Cross-section construction

© CGG | NPA Satellite Mapping
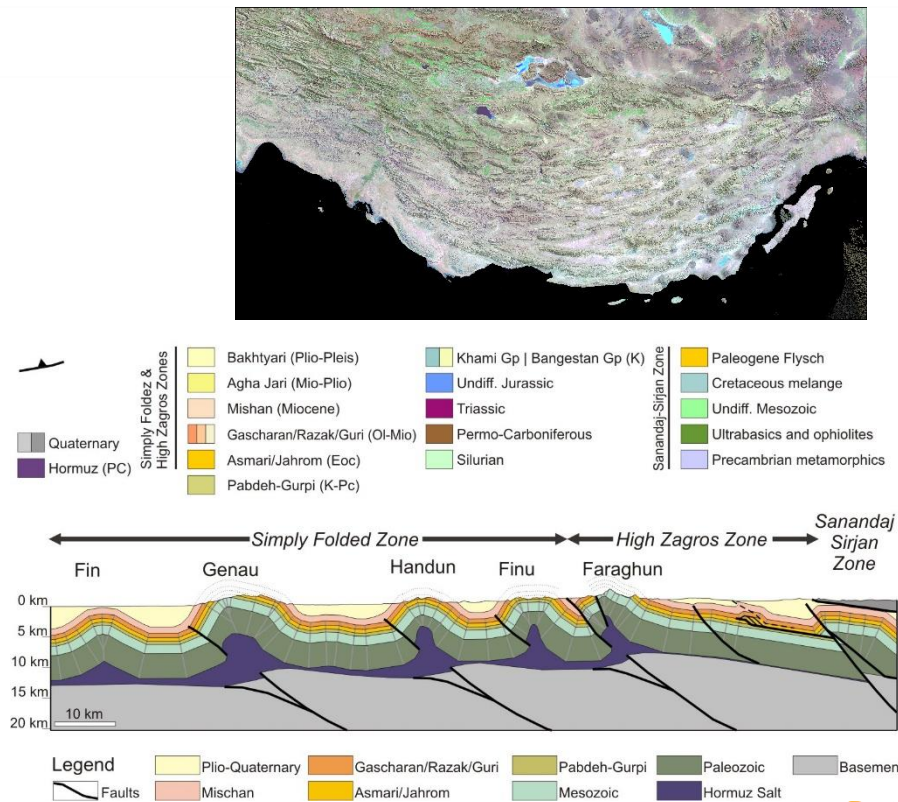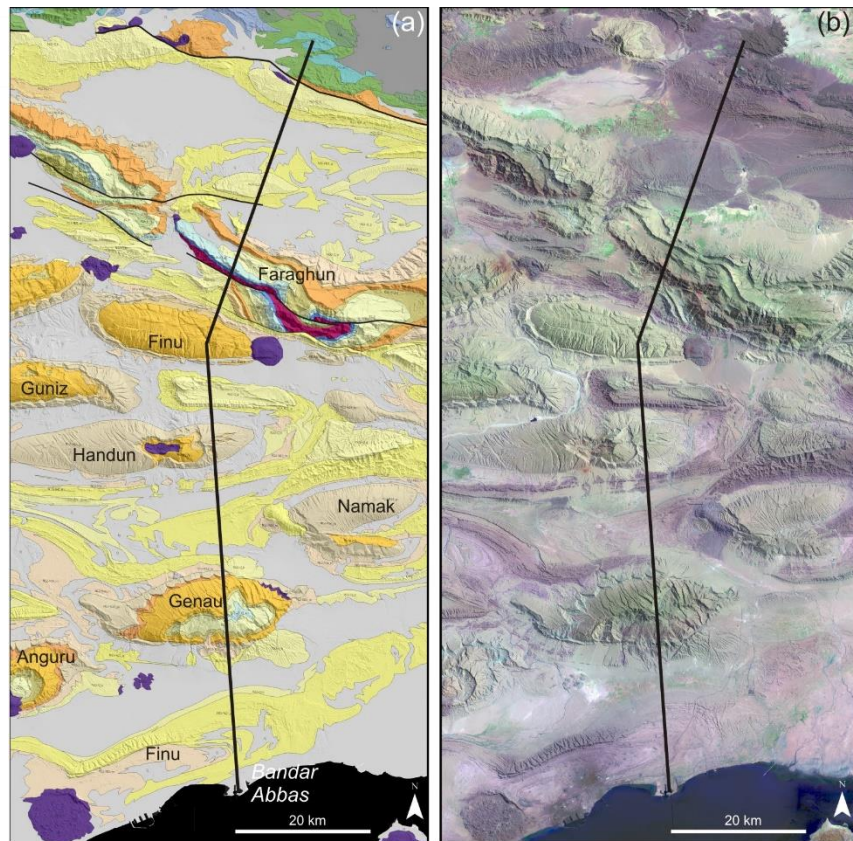
However not all terrain is ideal - An-Nafud Desert

20 km

© CGG | NPA Satellite Mapping

Sentinel 2 - Contrast enhanced

20 km

© CGG | NPA Satellite Mapping

Sentinel-1 Radar

20 km

© CGG | NPA Satellite Mapping
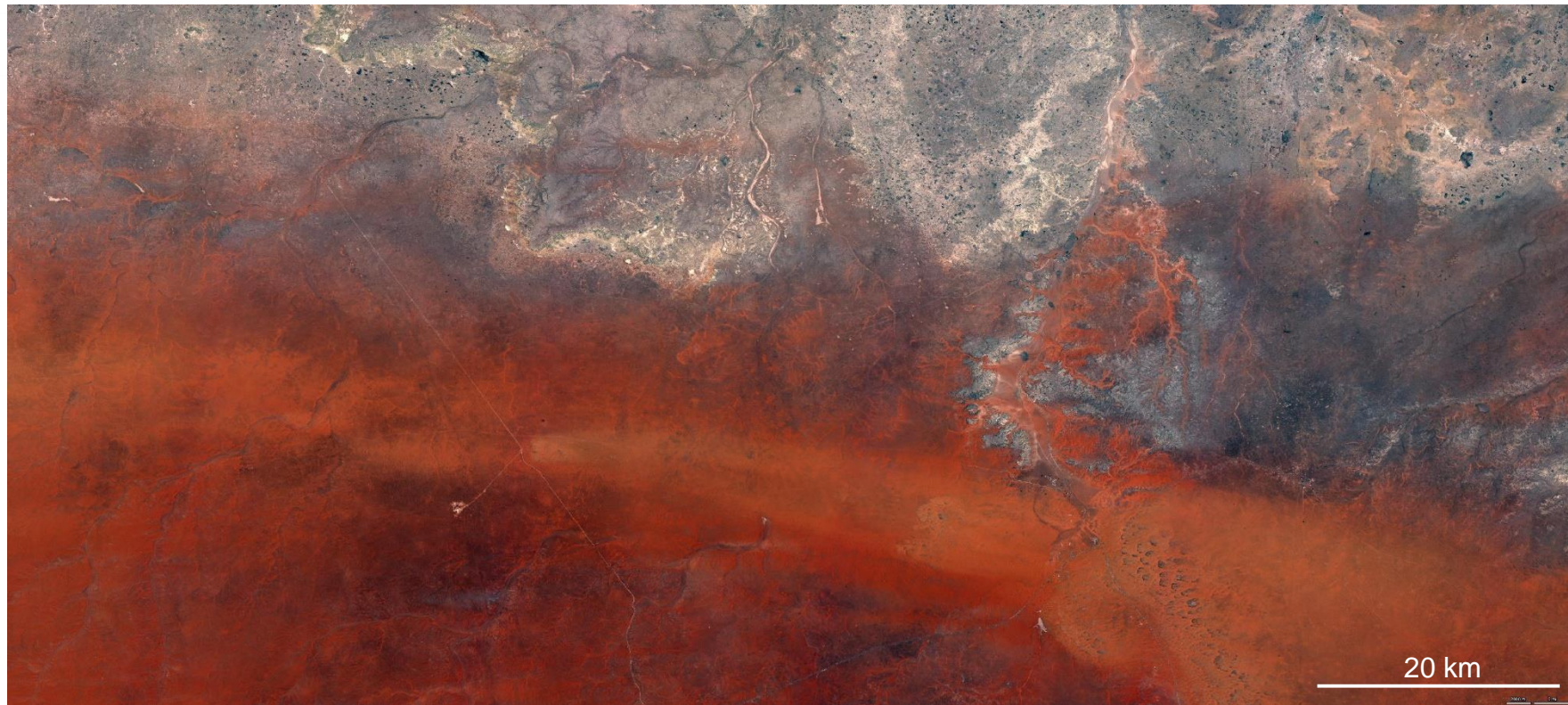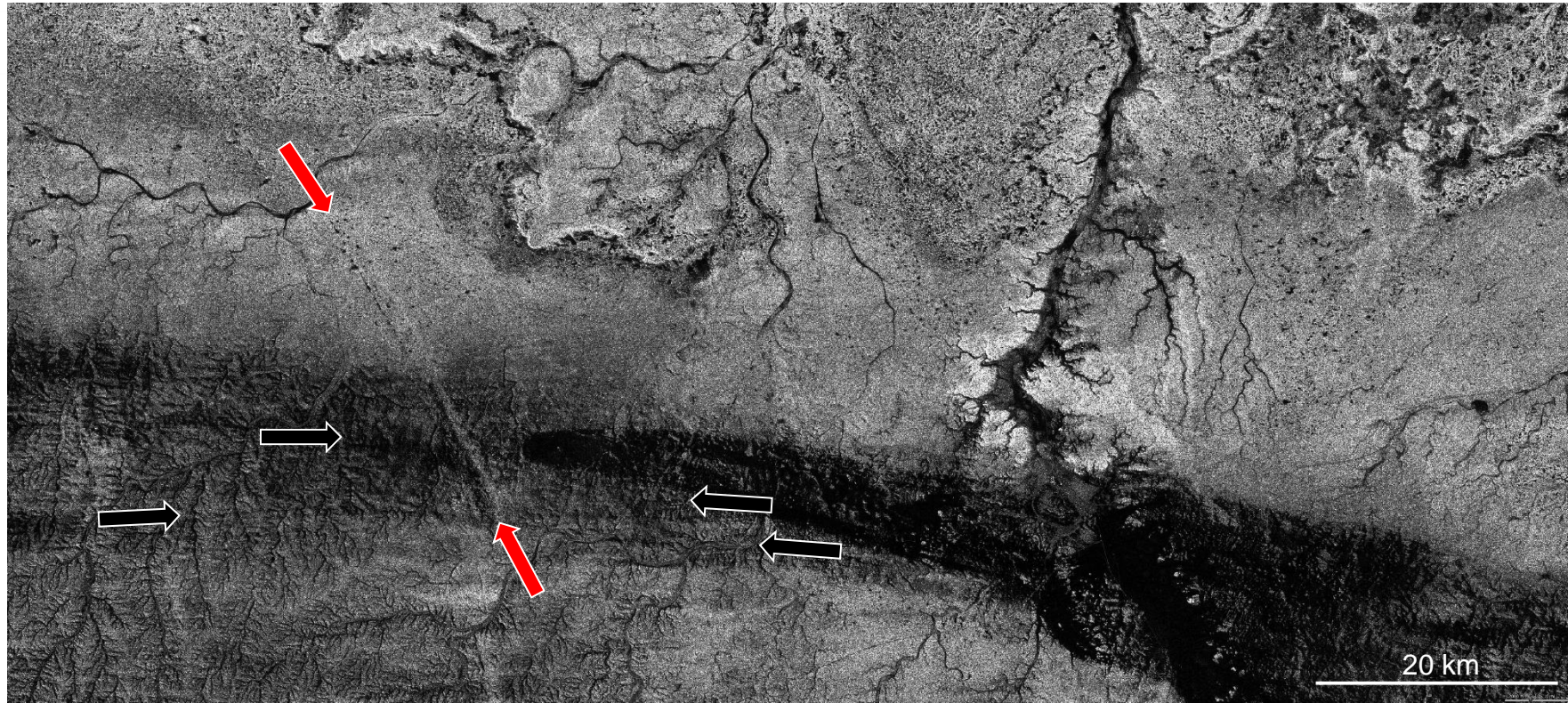
Sentinel 1 & 2 combined

20 km
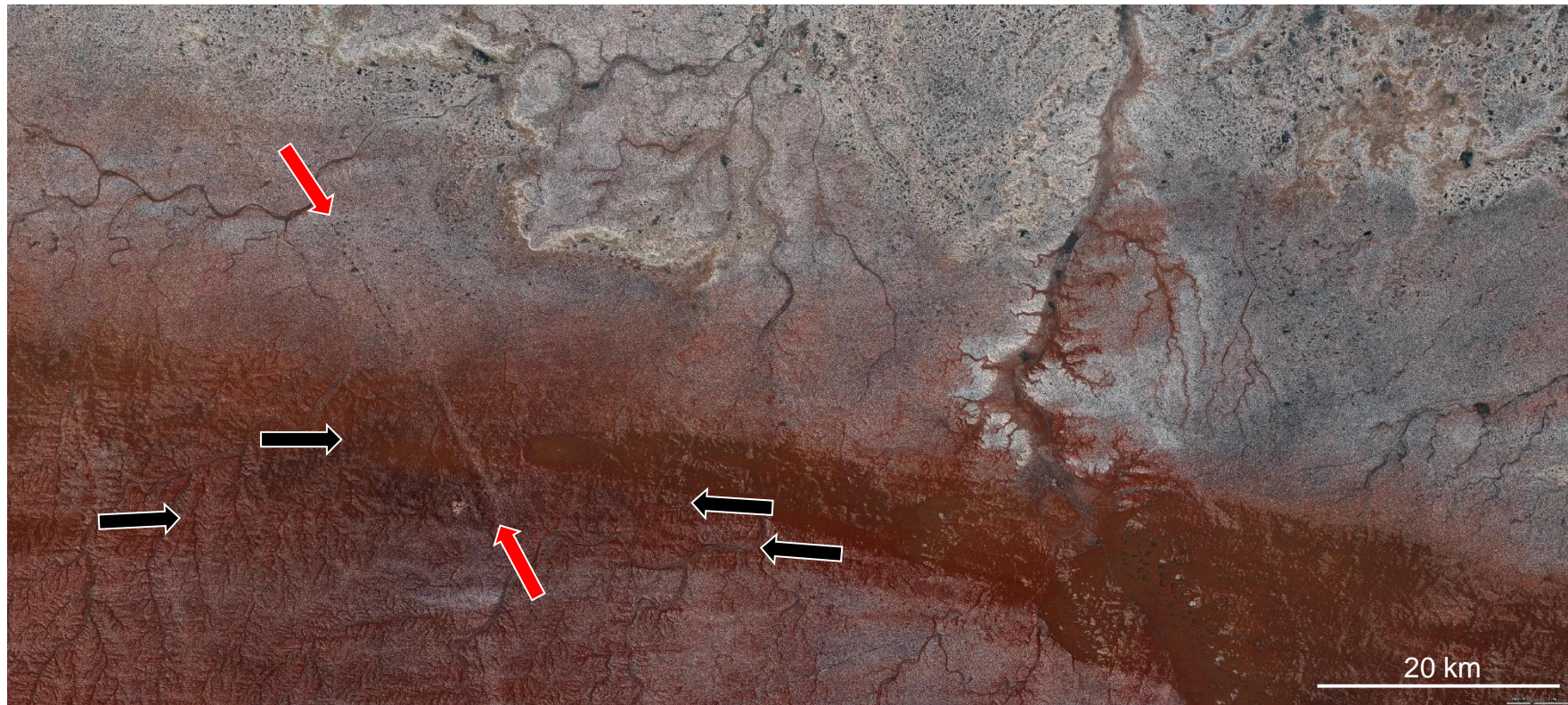
Seepage

What are Seeps?

- Seeps:
  - Seeps are the **surface expression of a migration pathway** along which **petroleum is currently flowing** driven by buoyancy from a sub-surface origin. *(Clarke & Cleverly, 1991)*
  - Onshore these often present as bitumen impregnations or rock alterations
  - Offshore seeps maybe seen on seafloor or as surface oil slicks on sea surface

200m

© CGG | NPA Satellite Mapping

Onshore Seeps

© CGG | NPA Satellite Mapping

Landsat 8 OLI data – Dezful Embayment

© CGG | NPA Satellite Mapping
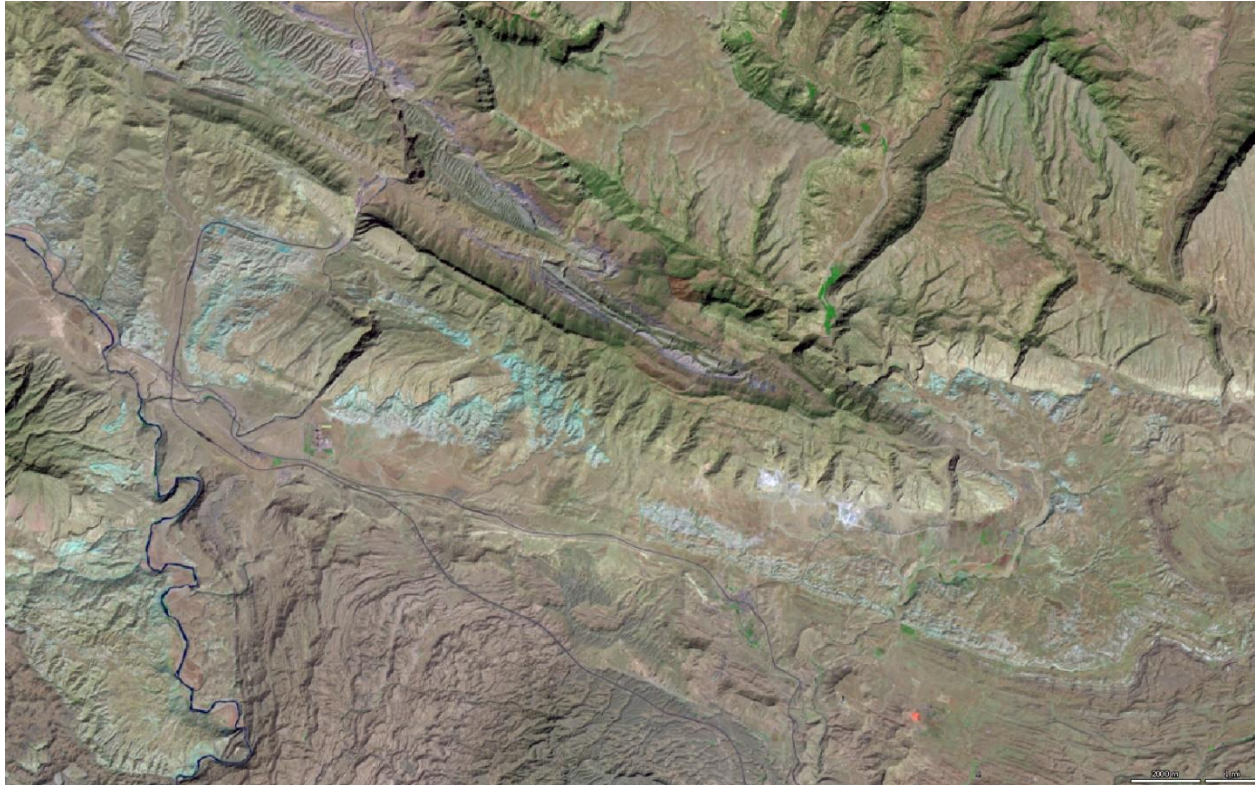
Mineral Mapping – ASTER highlights seepage alteration

Known seeps

Legend:
- ☐ = 2 mineral pixels
- ☐ = 3 mineral pixels
- ☐ = 4 mineral pixels
- ☐ = 5 mineral pixels
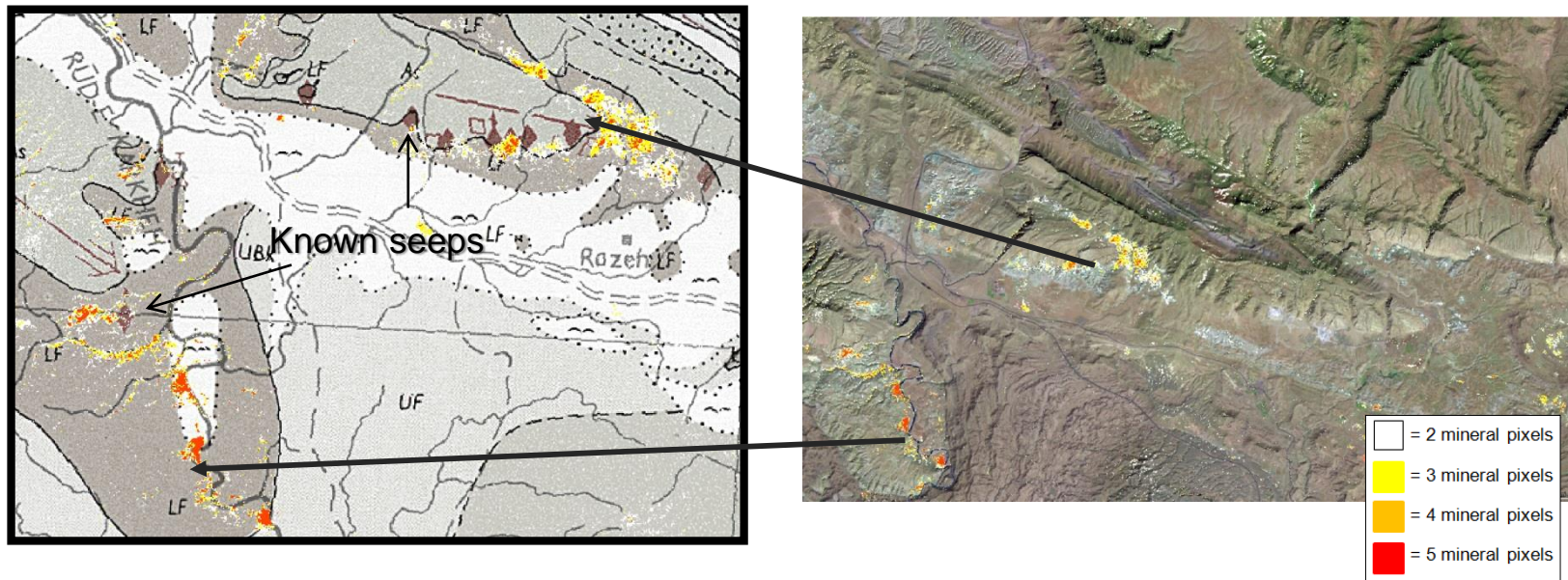
High correlation to known seeps

Offshore Seeps

What do offshore seeps look like?

- Offshore oil seepage most often presents as bubbling from the sea bed.
  - Sometimes this is in the form of oil bubbles directly
  - More commonly as gas bubbles with an oil surfactant coating

Green Canyon, Gulf Of Mexico
Oil Bubbles

Santa Barbara, California
Methane Bubbles

Satellite seepage detection

Surface oil slick suppressing capillary waves

Surface capillary waves

Oil coated bubbles

current

Seepage detection principle

Seepage slick on SAR data
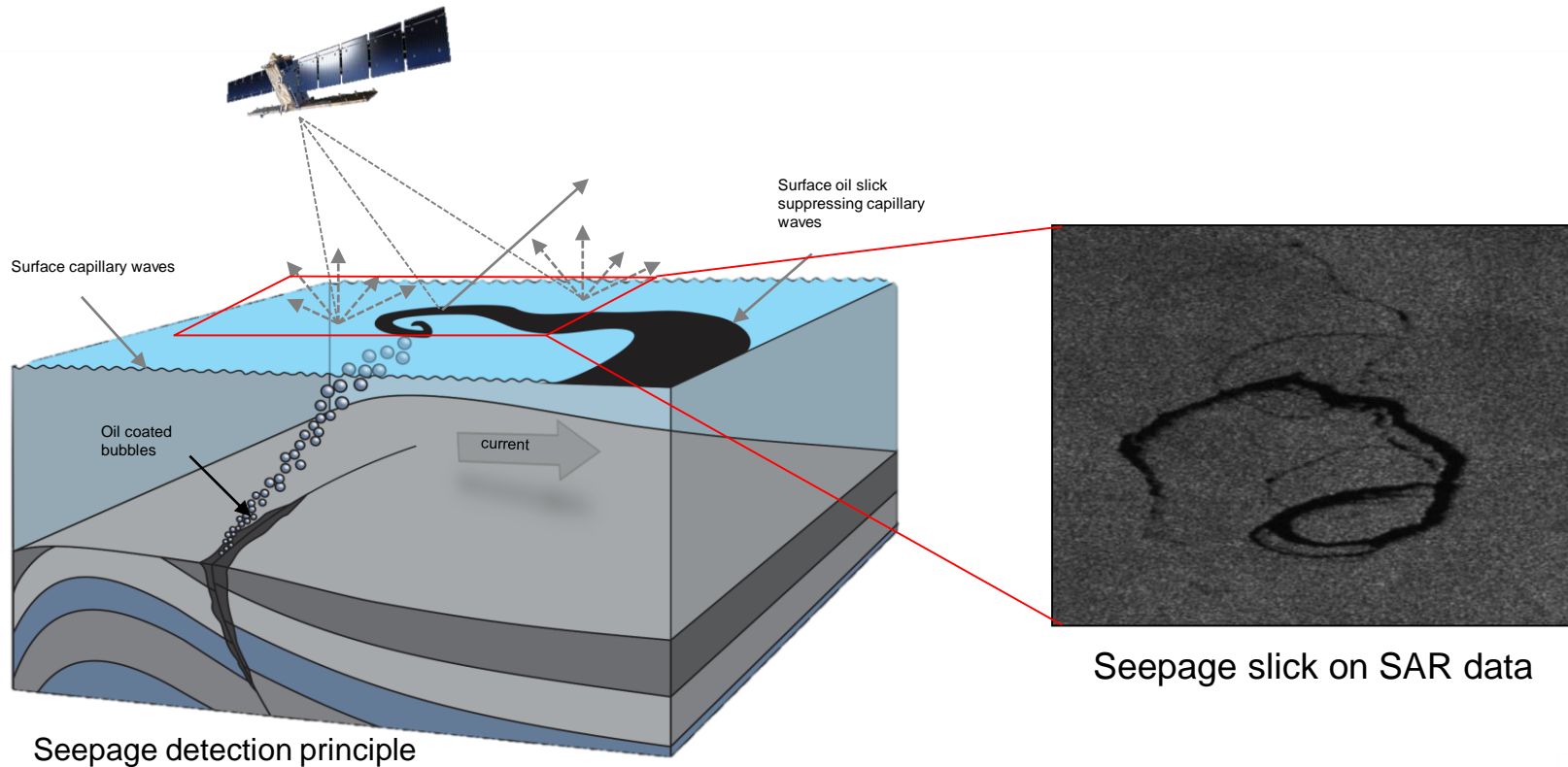
The importance of weather compliance
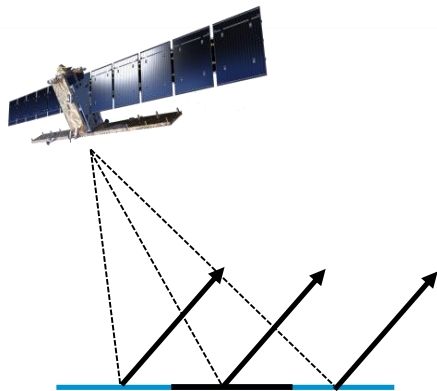
Wind speed 0 – 1m/sec
(surface too calm)
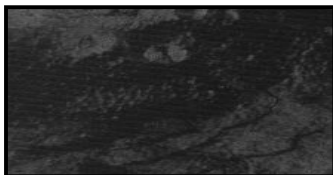
Wind speed 2.5 – 4.6m/sec
(ideal surface conditions)
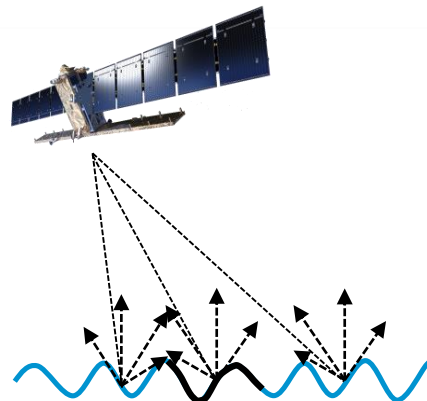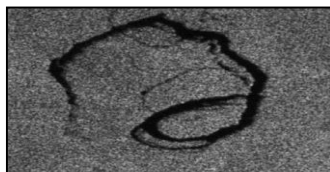
Wind speed > 5m/sec
(surface too rough)

Oil not detectable

Oil detectable

Oil not detectable

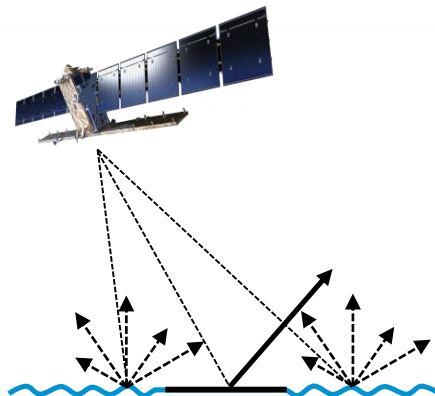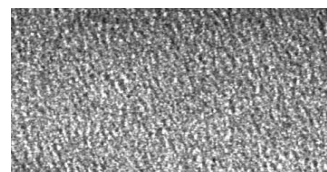# Slicks are due to wave damping – 3 possible origins

What are the 3 origins?

- Pollution Slicks – mostly illegal ship dumping; by far the largest category
- Natural Film slicks – formed by organic material (plankton, algal blooms, etc) which only form at very low wind speeds
- Natural Oil Seeps – our target group
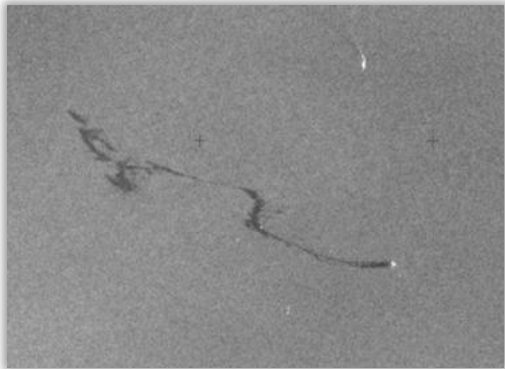
Pollution Slick

Natural Film Slicks
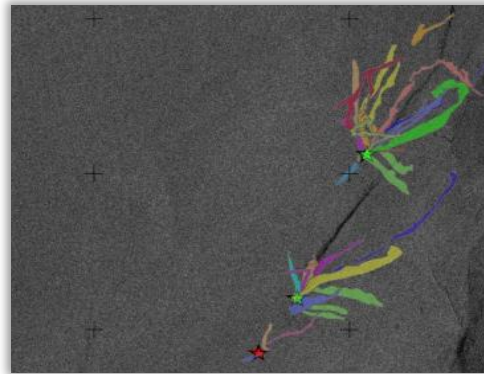
Natural repeating oil seeps

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Seep Explorer
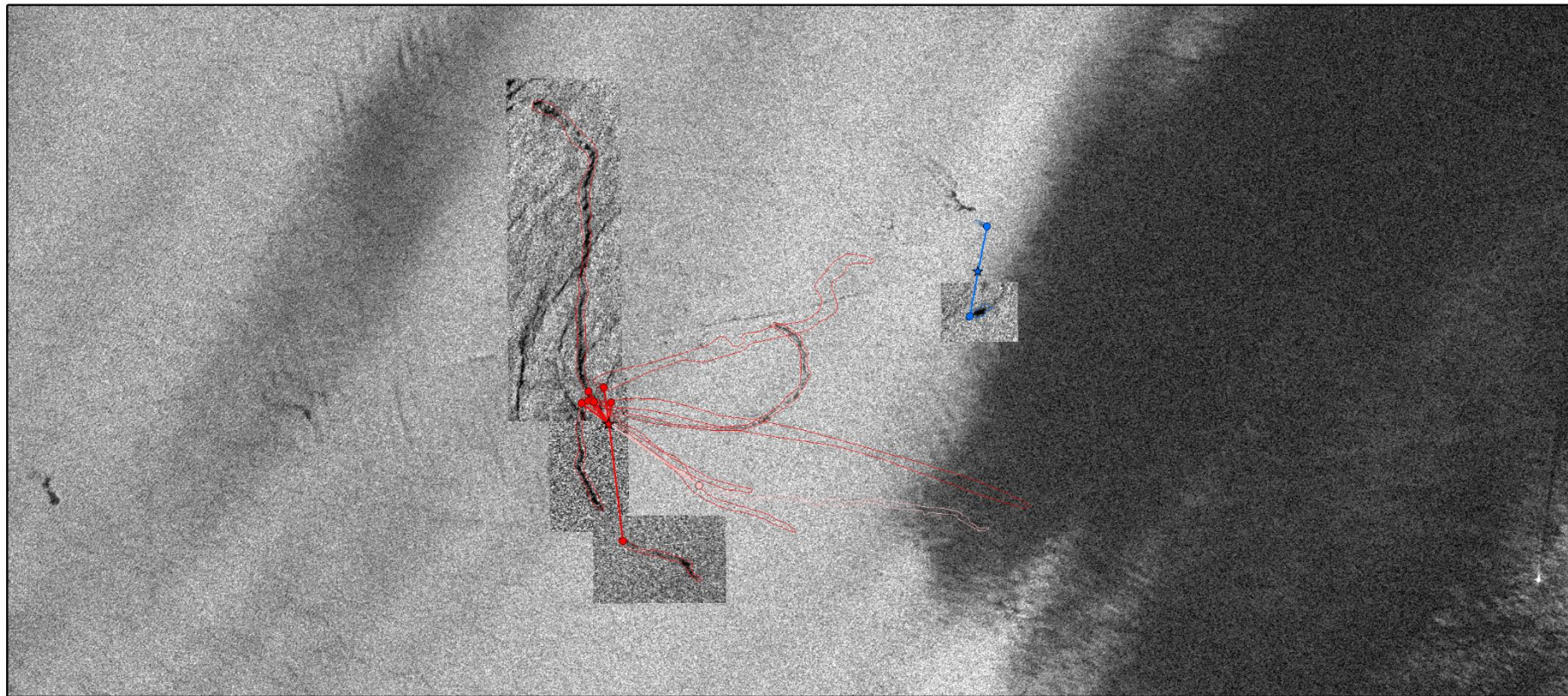
Repeat Locations category

★ 81 – 90 (red)	▭ Seepage Slick Second Rank
★ 61 – 70 (blue)	▭ Seepage Slick Third Rank
	▭ Priority Unassigned Slick

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019

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Seep Explorer
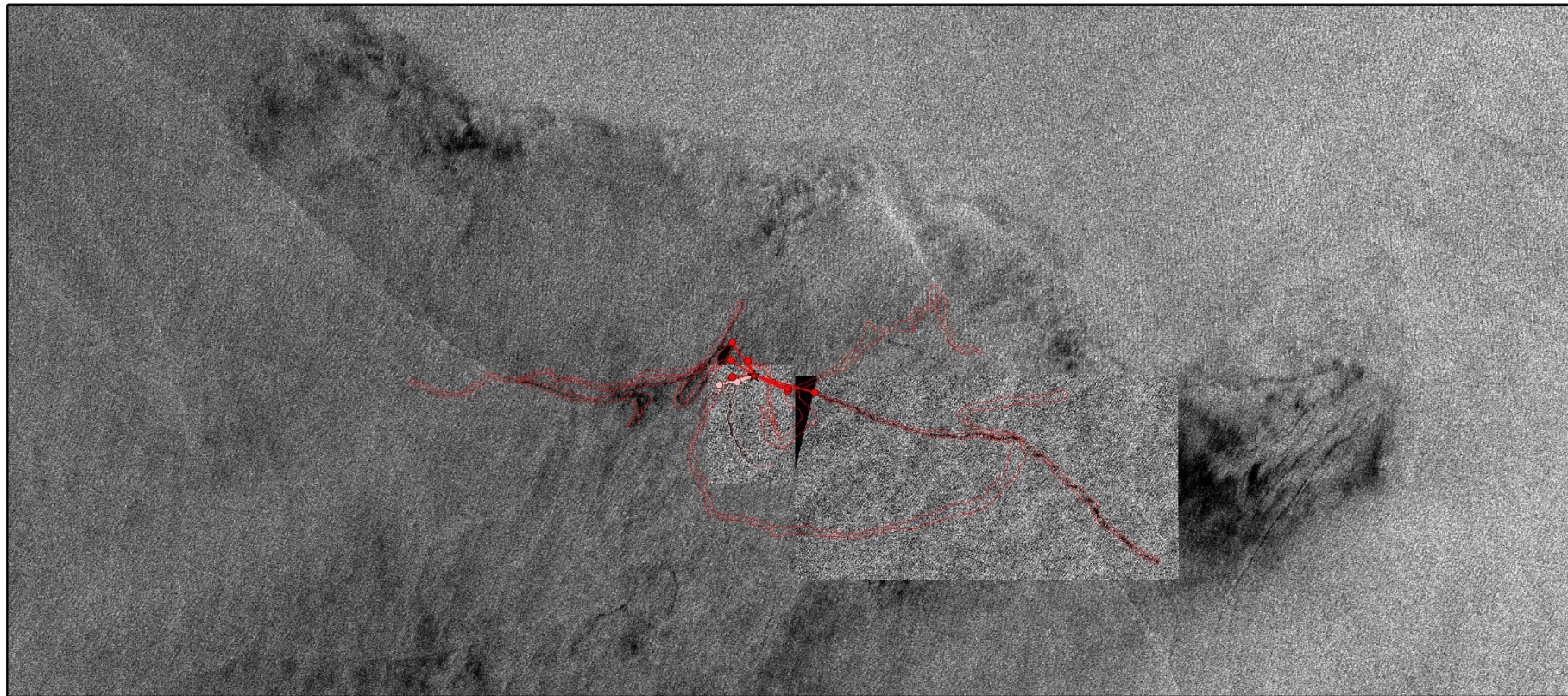
Category

Repeat Locations

Seepage Slick Second Rank

★ 81 - 90

Seepage Slick Third Rank
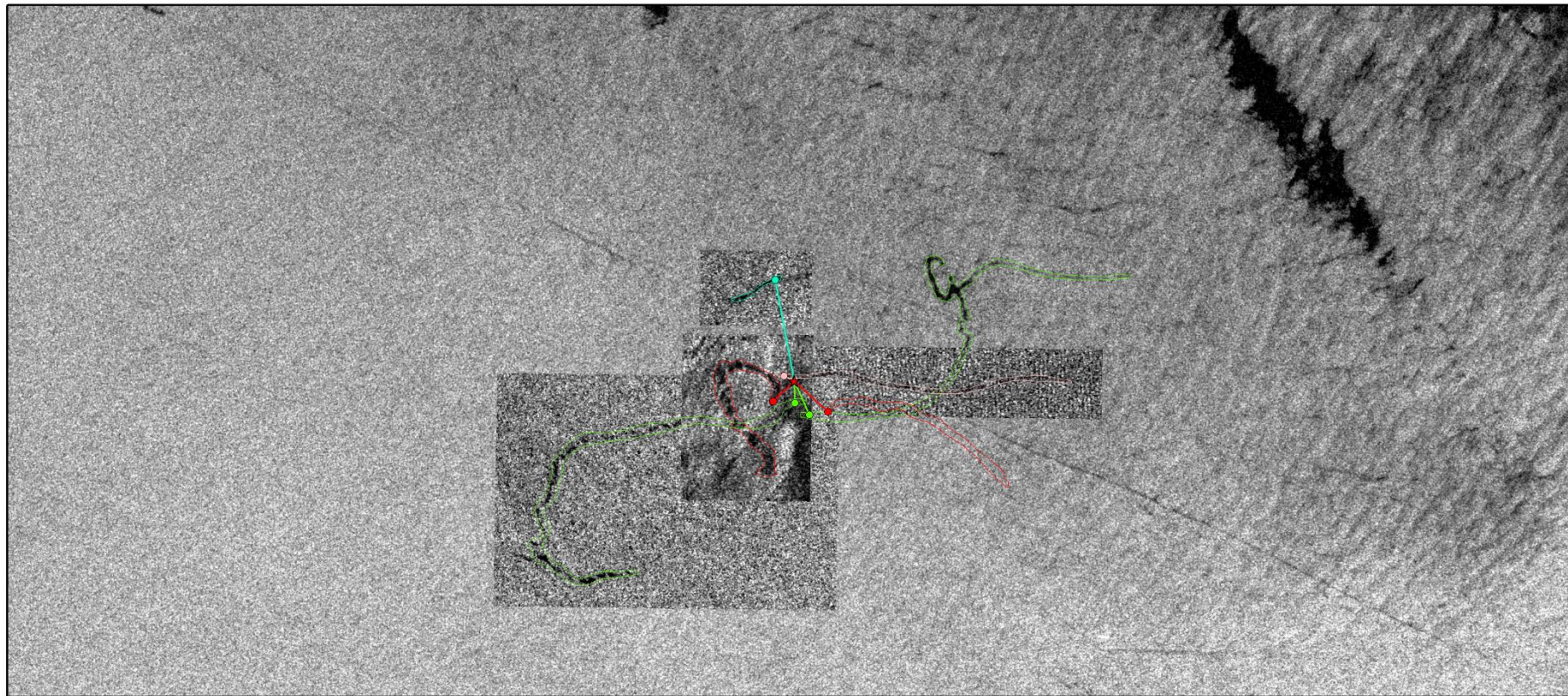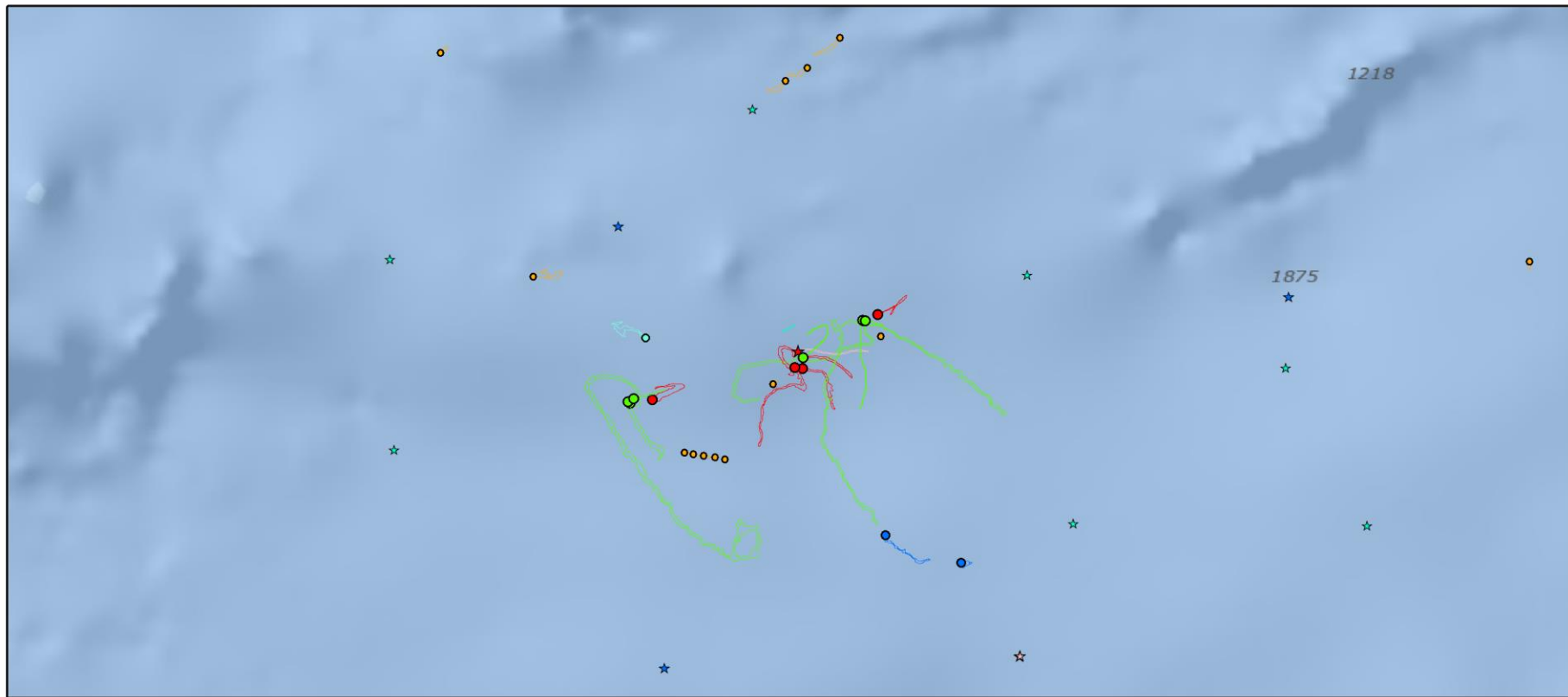
Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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N

CGG
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Seep Explorer

Category

Repeat Locations

— Seepage Slick First Rank

— Seepage Slick Second Rank

— Seepage Slick Third Rank

— Unassigned Slick

★ 81 - 90

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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Cyprus
Repeat Locations

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Seep Explorer

1218

1875

Category

Seepage Slick First Rank	
Seepage Slick Second Rank	
Seepage Slick Third Rank	
Unassigned Slick	

Repeat Locations

★ 81 - 90
☆ 71 - 80
★ 61 - 70
★ 50 - 60

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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N
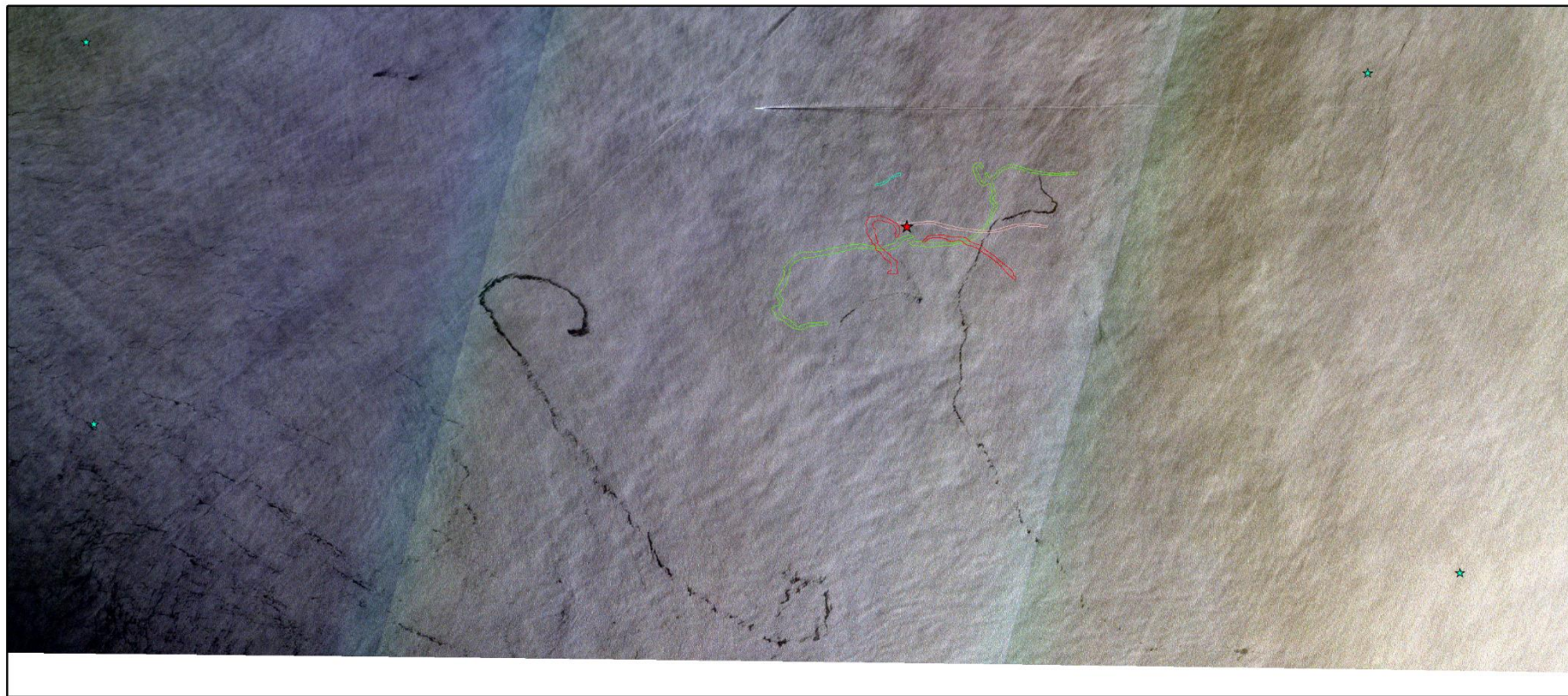
Category

- Seepage Slick First Rank
- Seepage Slick Second Rank
- Seepage Slick Third Rank
- Unassigned Slick

Repeat Locations

- ★ 81 - 90
- ☆ 50 - 60

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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N

Offshore Lebanon
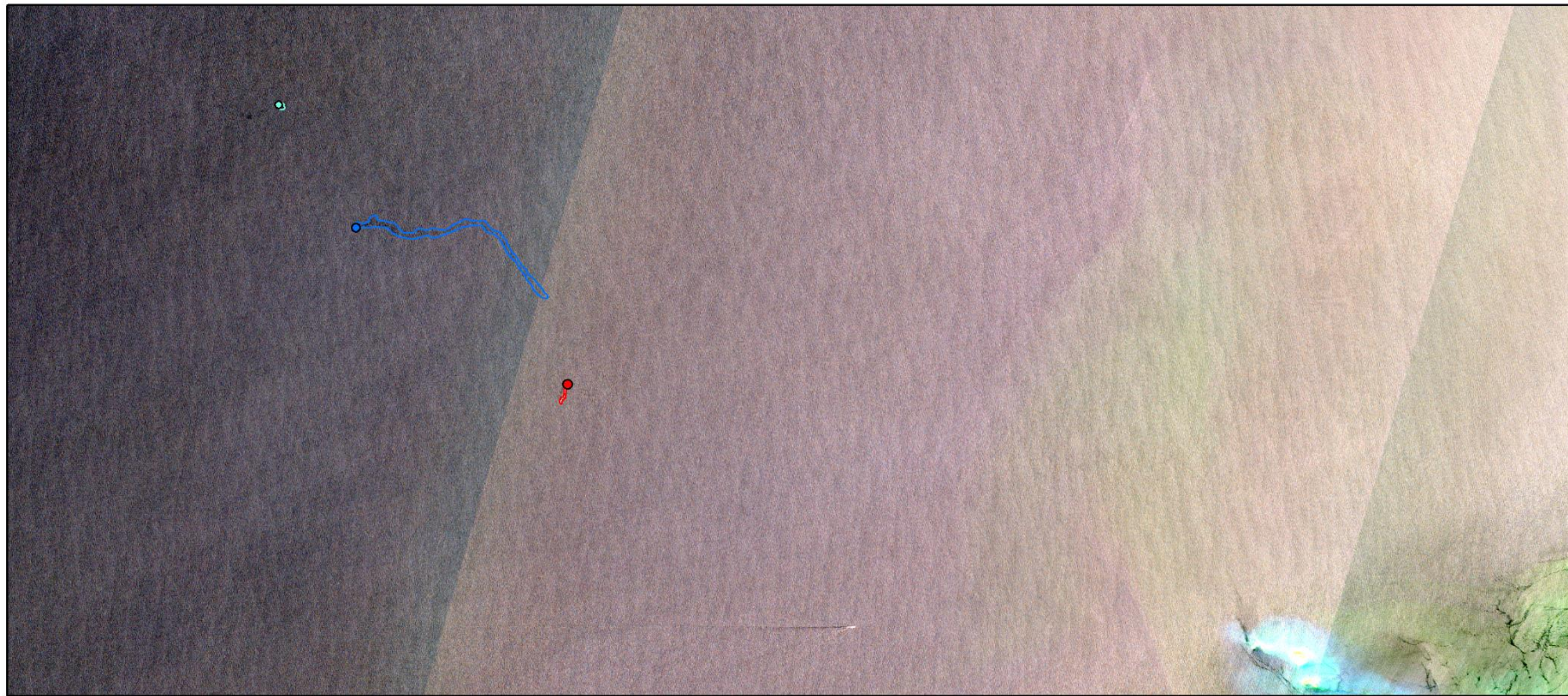
Category

▭ (red)	Seepage Slick Second Rank
▭ (pink)	Seepage Slick Third Rank

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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Seep Explorer

Category

▢	Seepage Slick Second Rank
▢	Priority Unassigned Slick
▢	Unassigned Slick

N

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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Northern Red Sea

© CGG | NPA Satellite Mapping

Category

Seepage Slick Second Rank
Seepage Slick Third Rank
Priority Unassigned Slick

Repeat Locations

★ 81 - 90
★ 61 - 70

N

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
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Seep Explorer

Category

Seepage Slick Second Rank	(red)
Seepage Slick Third Rank	(dark red)
Priority Unassigned Slick	(blue)

Repeat Locations

★ 81 - 90
★ 61 - 70

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 17/06/2019
© CGG | NPA Satellite Mapping 2019

Category

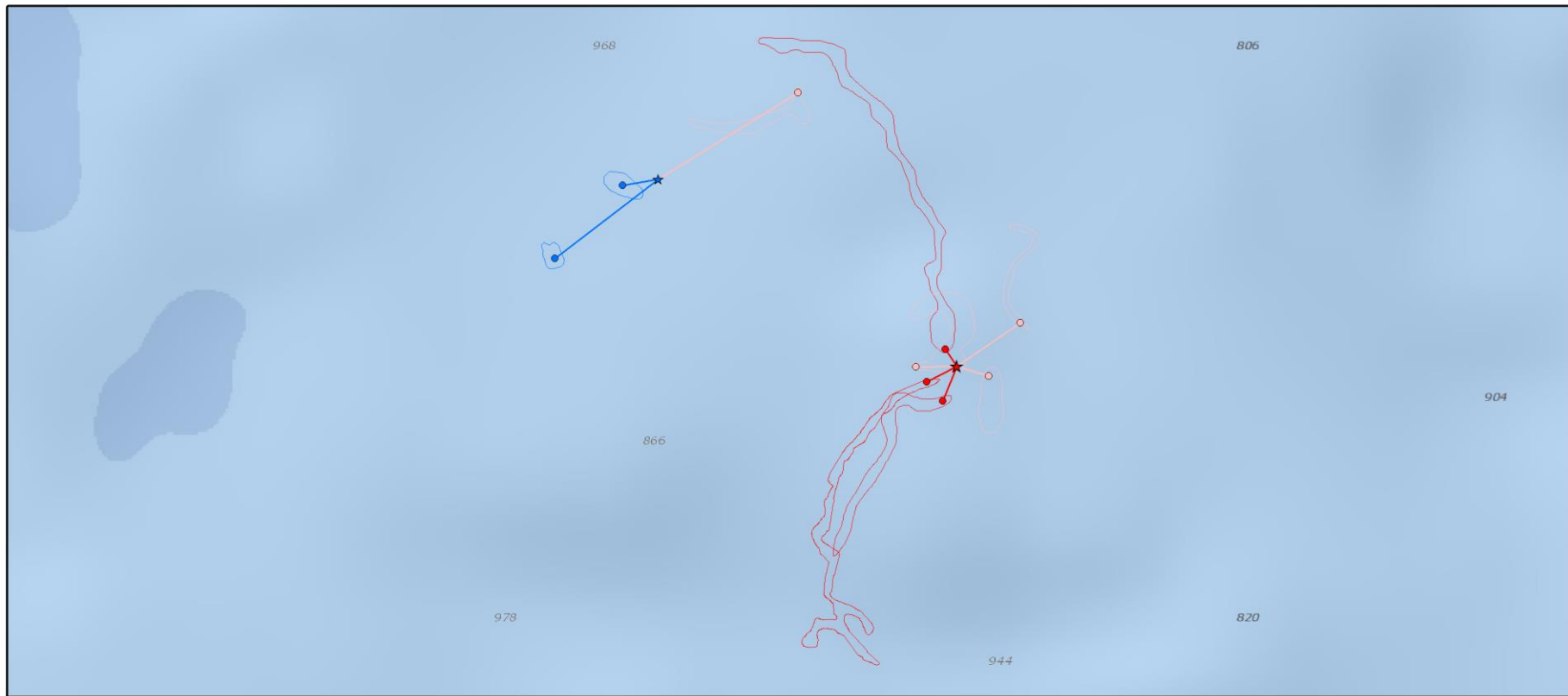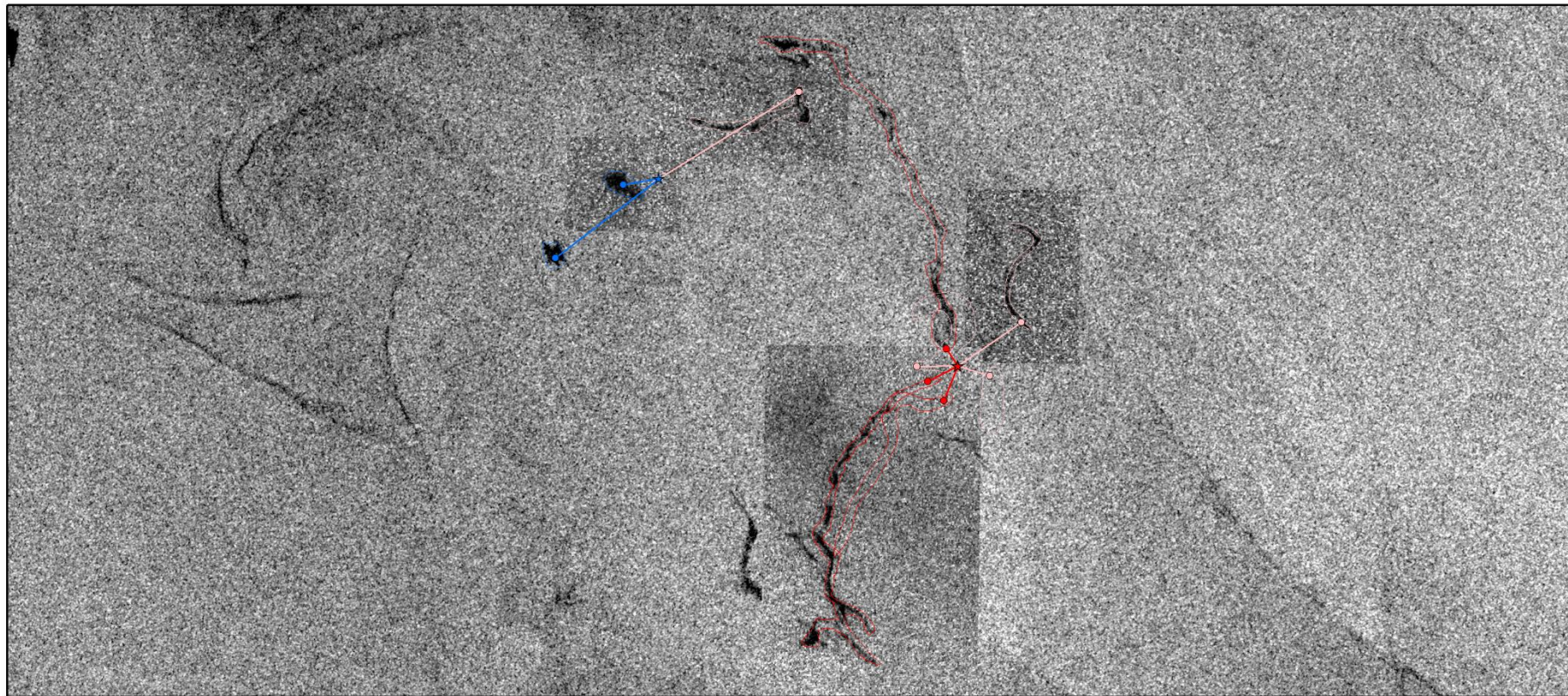● Seepage Slick First Rank
● Seepage Slick Second Rank

Score Percent

★ 91 - 100

Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 24/06/2019
© CGG | NPA Satellite Mapping 2019

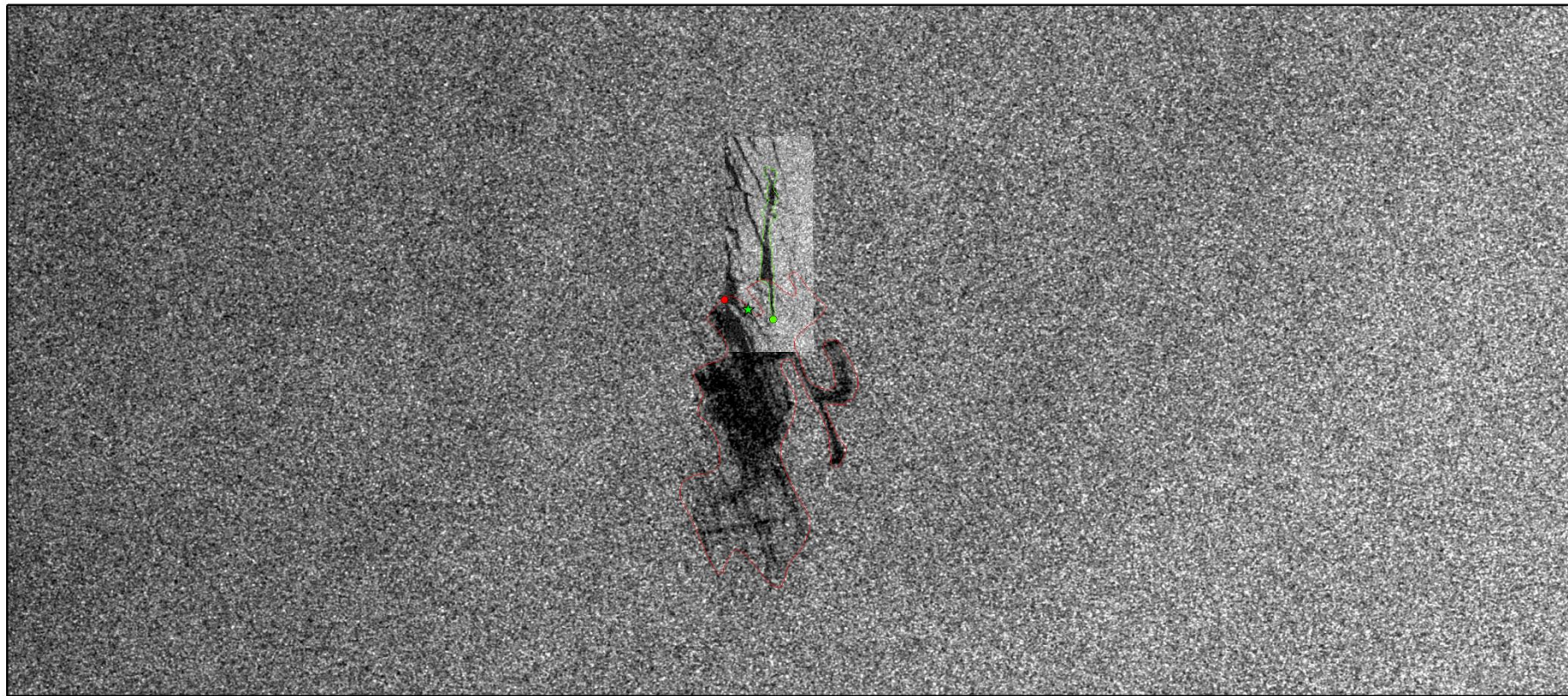Coordinate System: WGS84 / Geographic
Datum: WGS 1984
Units: Degree
Accurate as of 21/06/2019
© CGG | NPA Satellite Mapping 2019

Conclusion

- The Middle East lends itself to remote sensing

- Low cost exploration
  – Accurate mapping
  – Valuable intelligence – pre license commitment

- Nearly all environments satellite Remote Sensing can help
  – Frontier
  – Mature basins
  – Onshore
  – Offshore

- Not just exploration, scope for monitoring
  – INSAR – Production
  – Pollution Monitoring

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Thank you