20 years of oil routes

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20 years of Radar monitoring from ERS-1

ERS-1

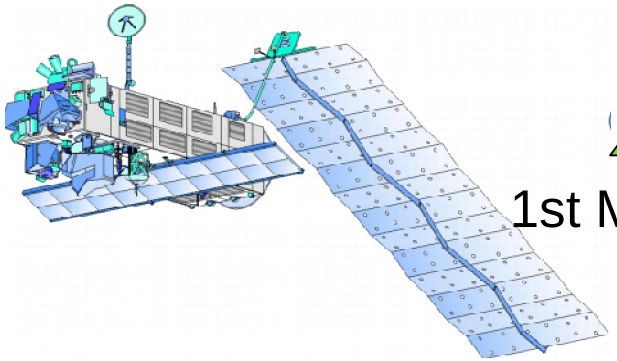
17 July 1991

March 2000

ERS-2

21 April 1995

July 2011



Envisat

1st March 2002

Sentinel-1

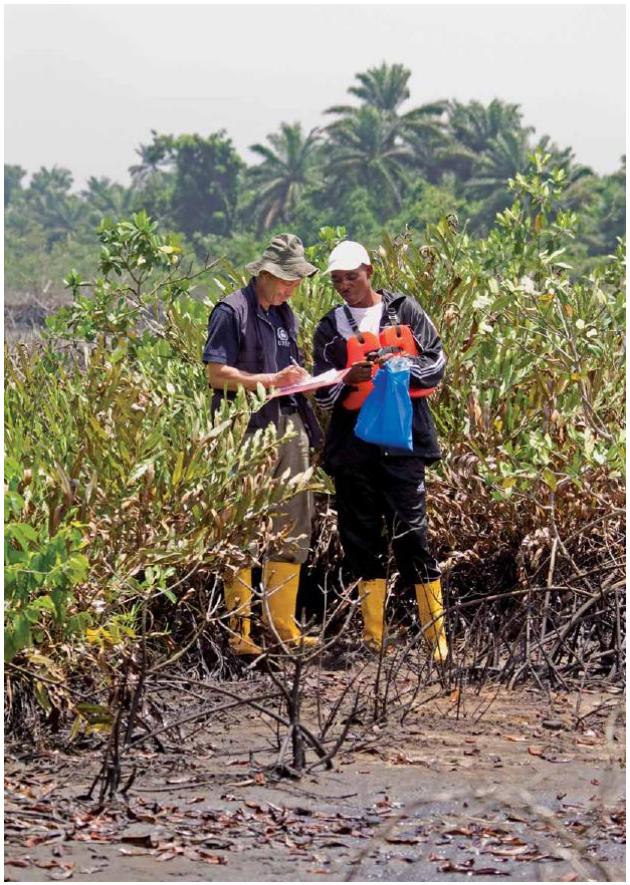
end 2012 ?

Importance of oil pollutions

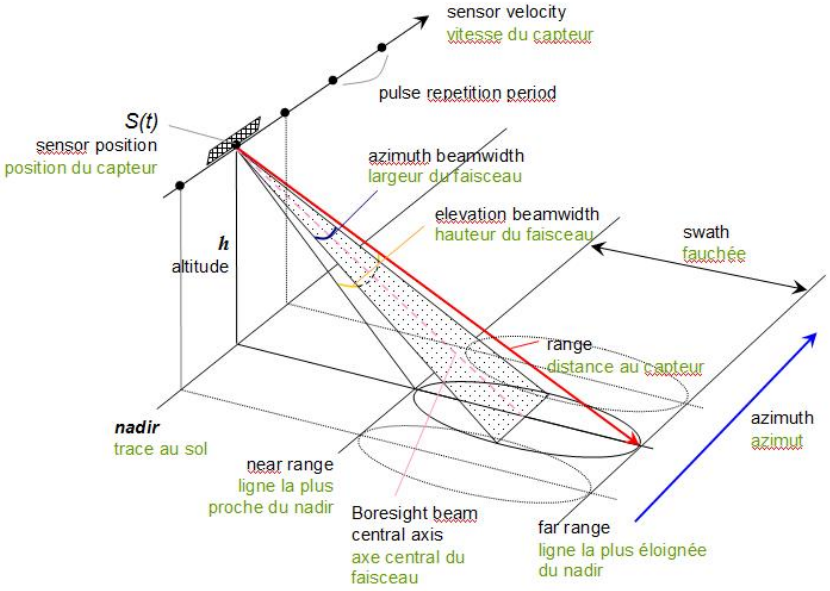
- Mexico Gulf - 20th April 2010

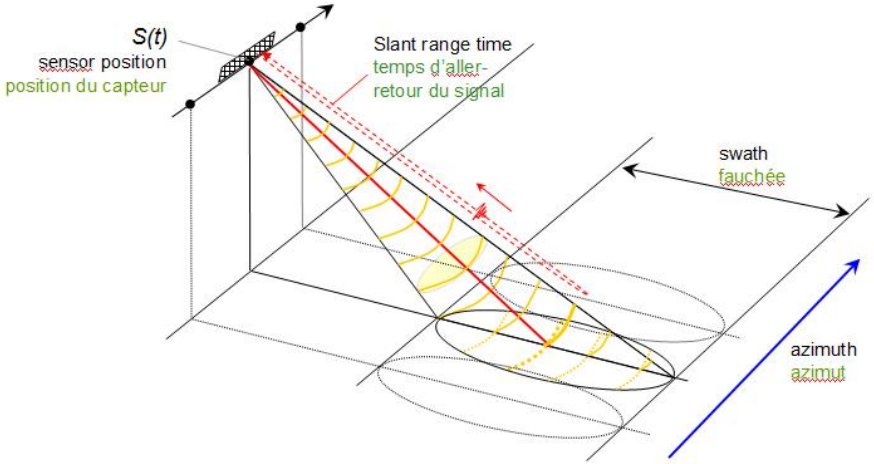
Importance of oil pollutions

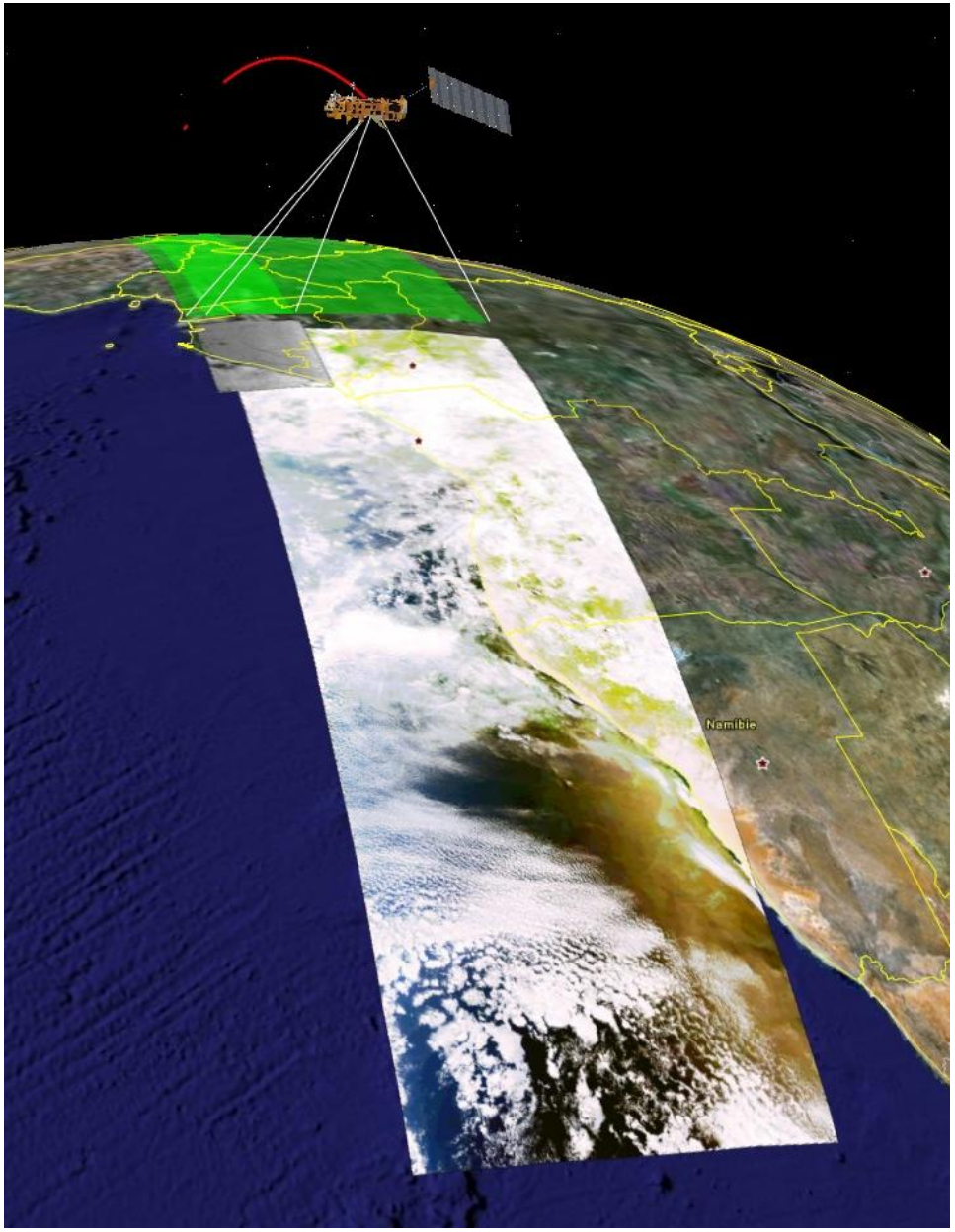
- Nigeria UNEP report - August 2011
  - http://www.unep.org/dnc/CountryOperations/Nigeria/EnvironmentalAssessmentofOgonilandreport/tabid/54419/Default.aspx



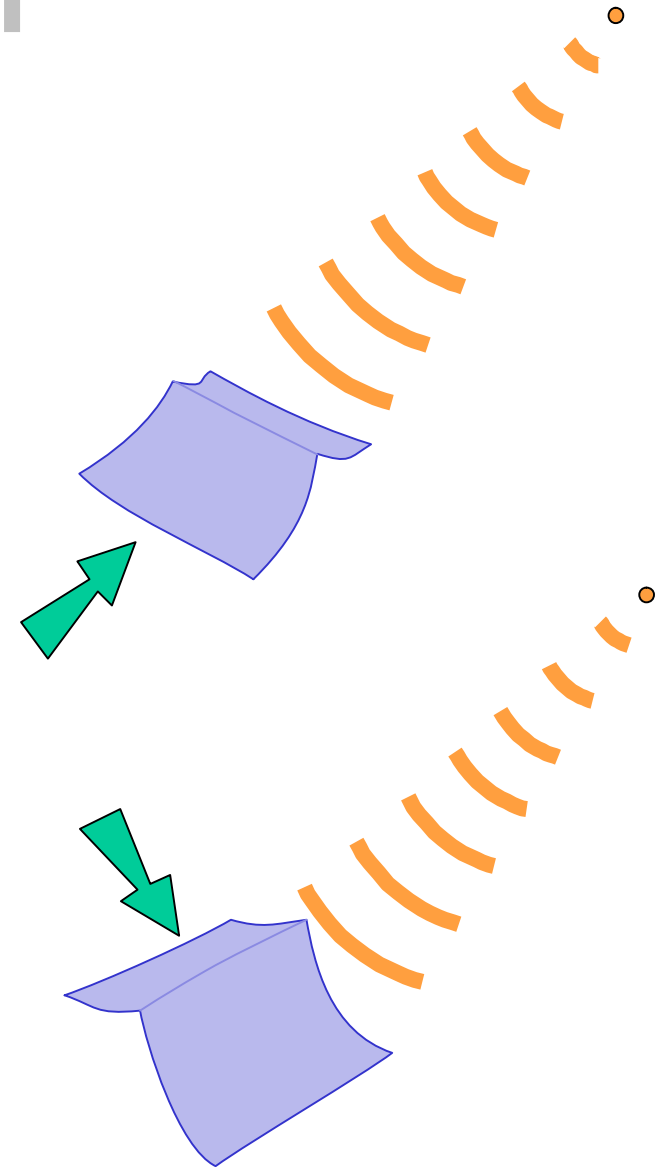
Observing the Earth with visible and radar

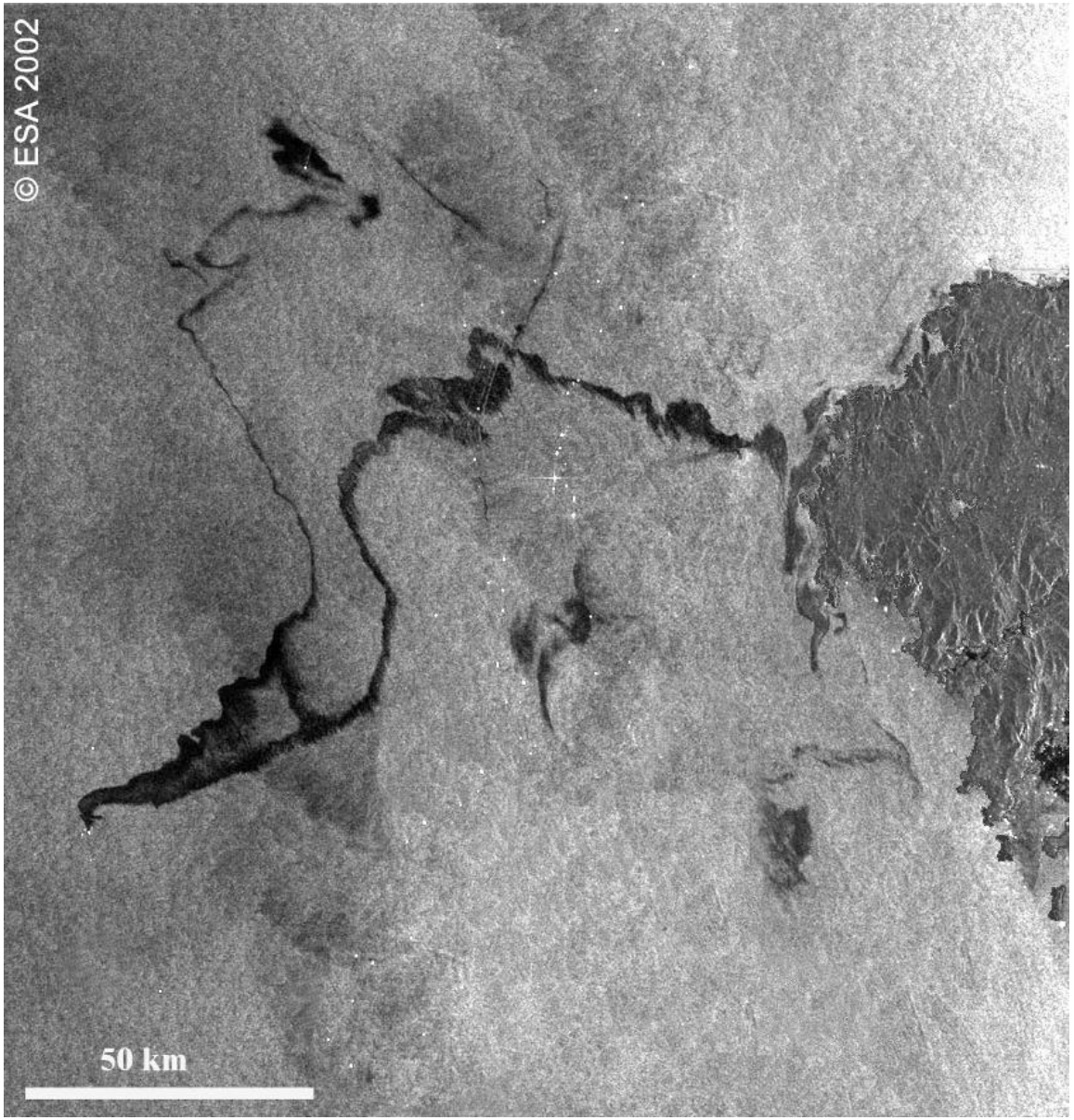




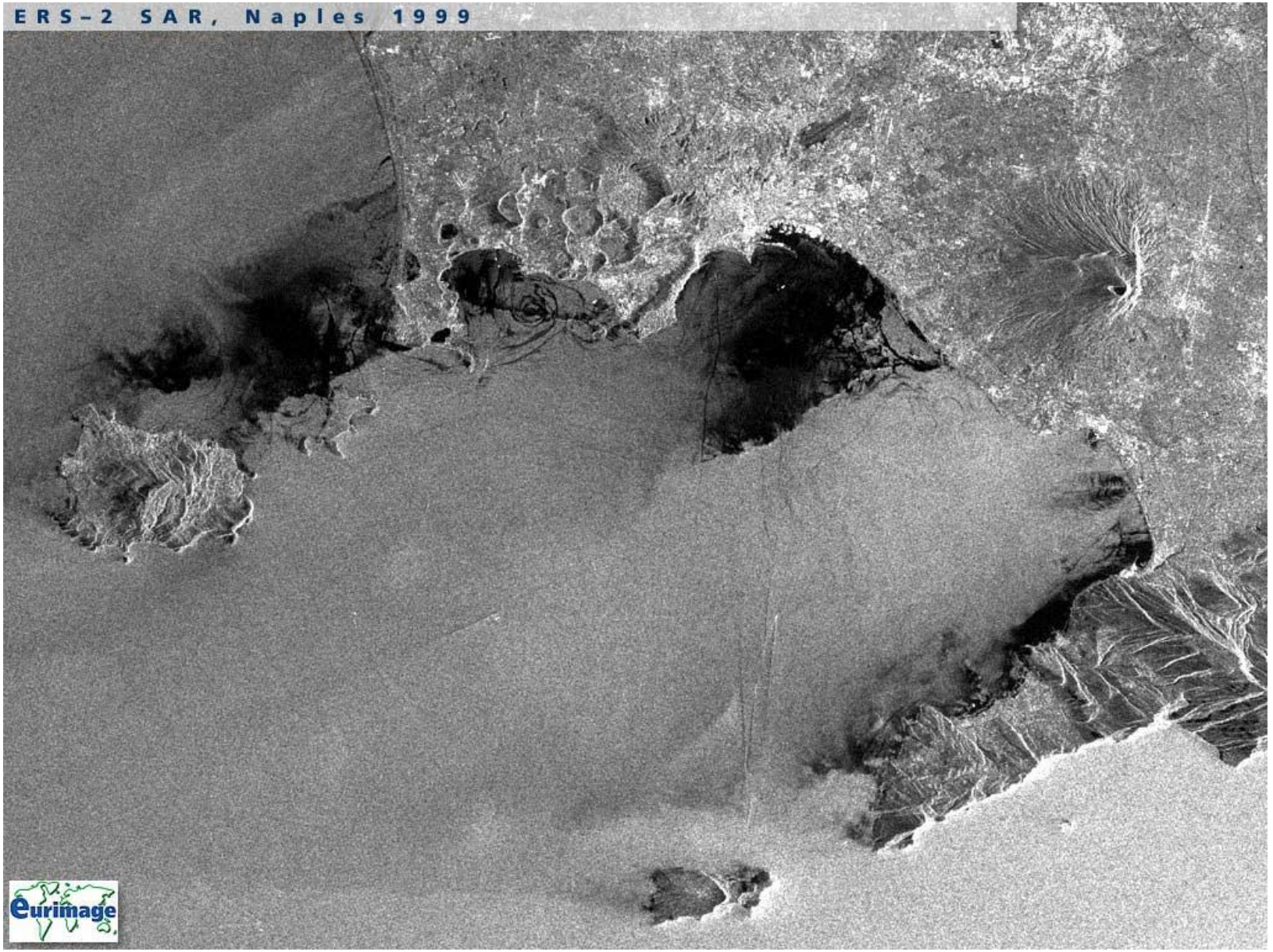


Why oil is appearing black ?

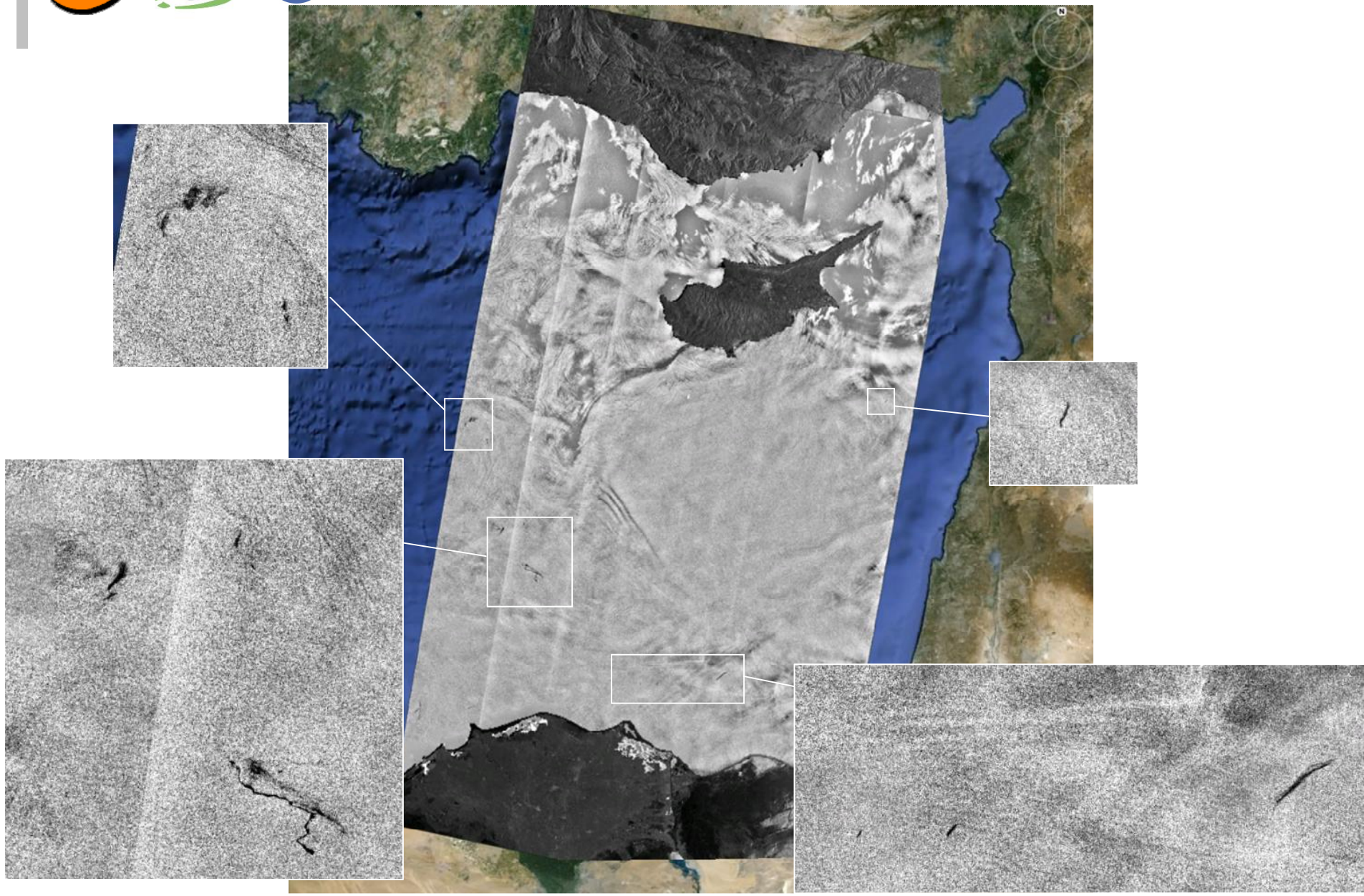




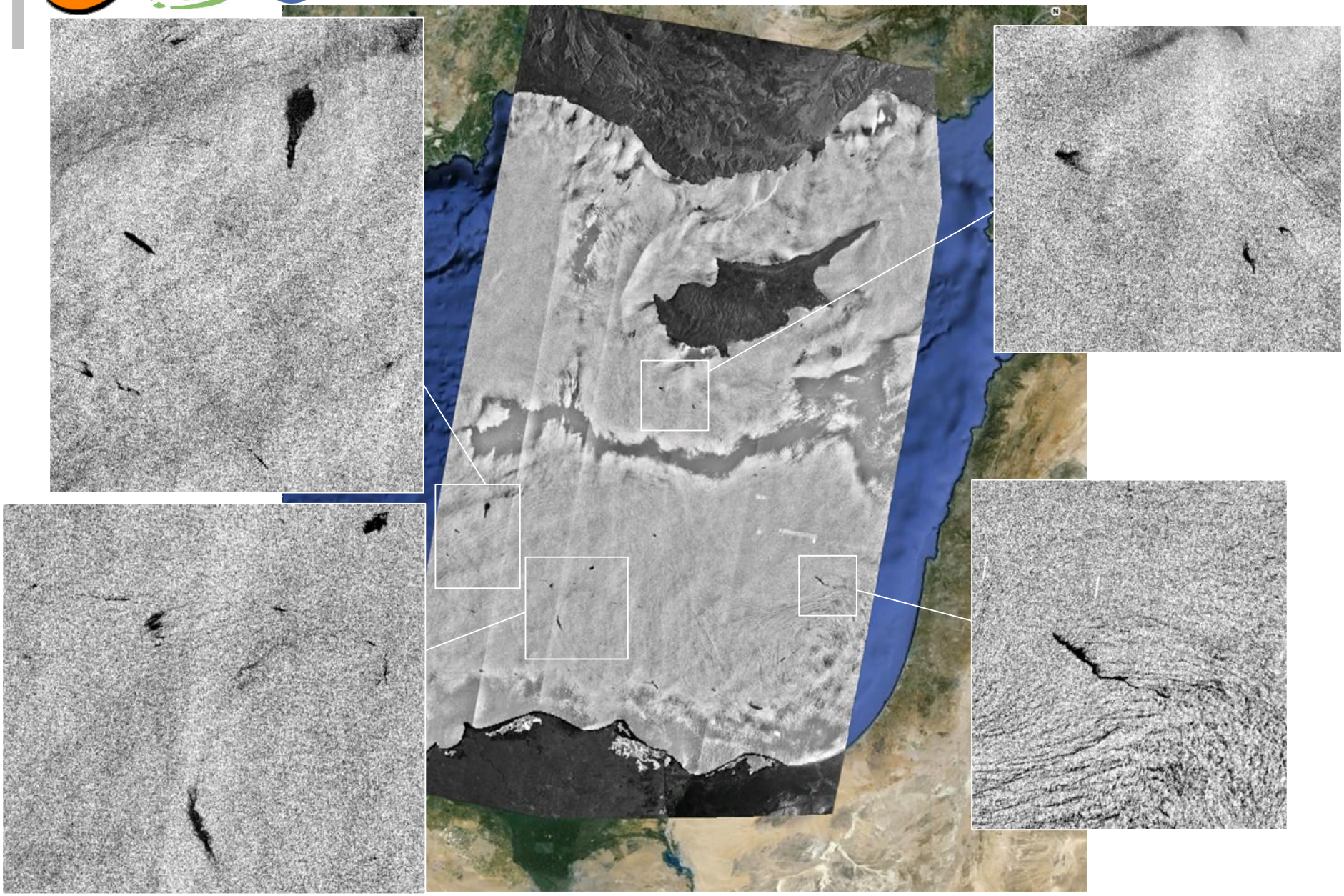
All black objects are not always oil !



Envisat / ASAR / WSM on 14/04/2008



Envisat / ASAR / WSM on 23/06/2008

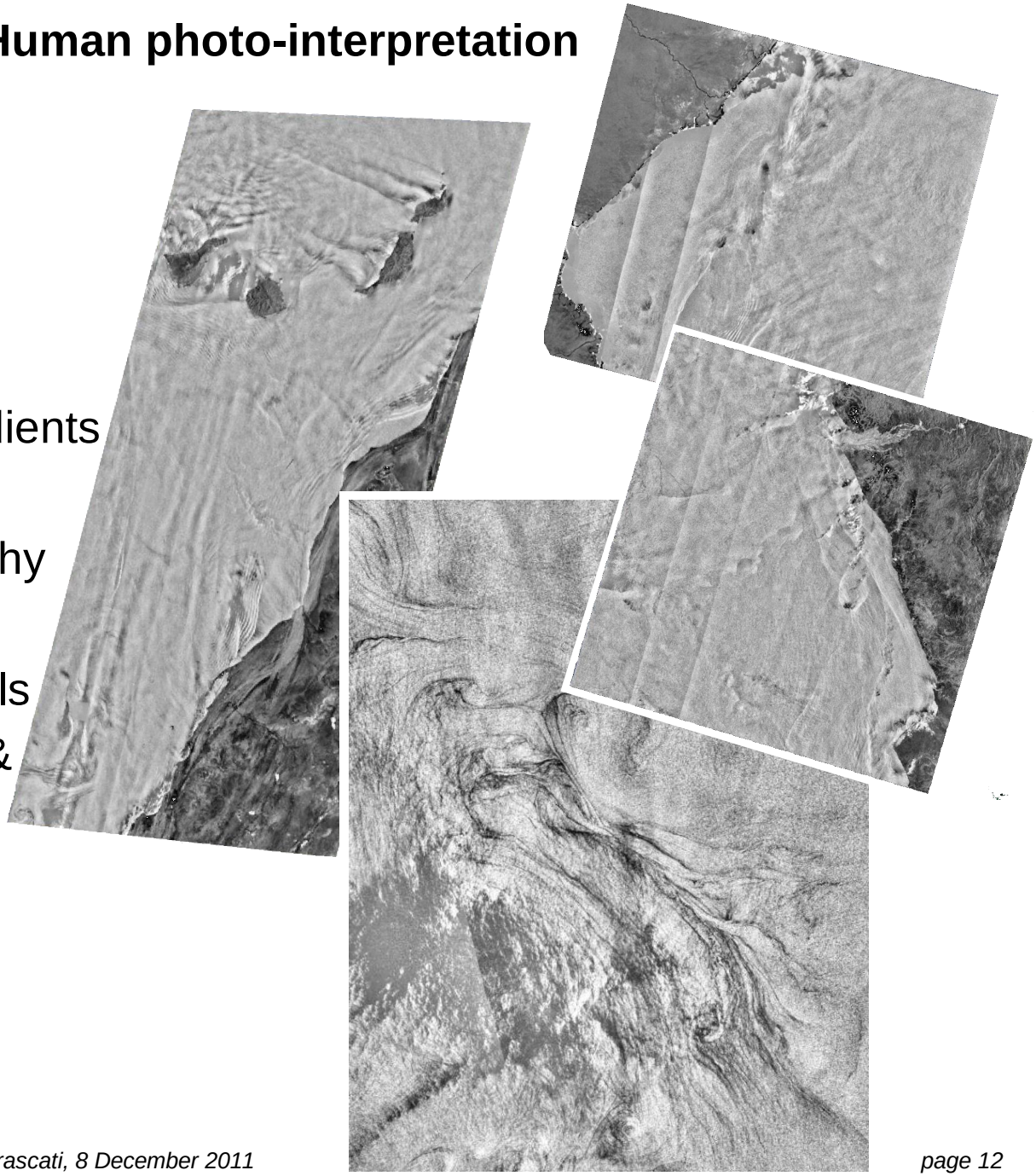


The “20 years of oil routes” project - Phases

- Algorithms development and qualification
  - Huge bibliography
  - Scene selection
  - Human photo-interpretation
  - Software development
  - Qualification
- Massive production
  - Agreement with ESA
  - Planned in 2012
- Cartography
  - Map production
  - Press releases

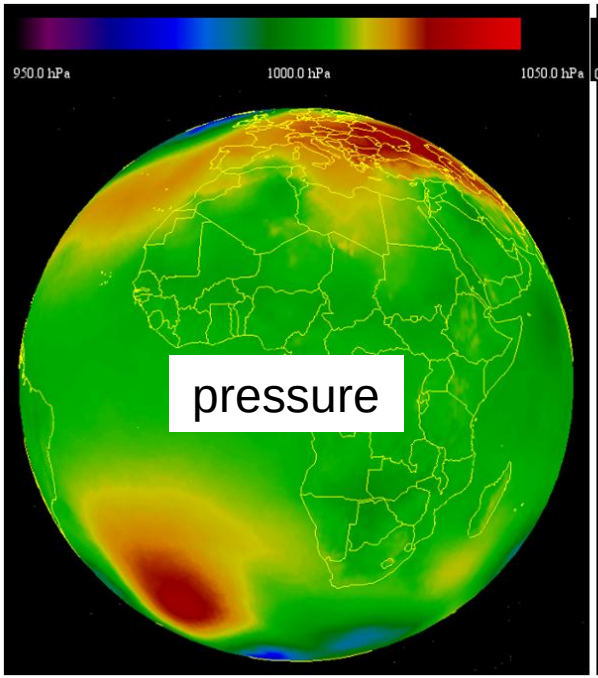
Human photo-interpretation

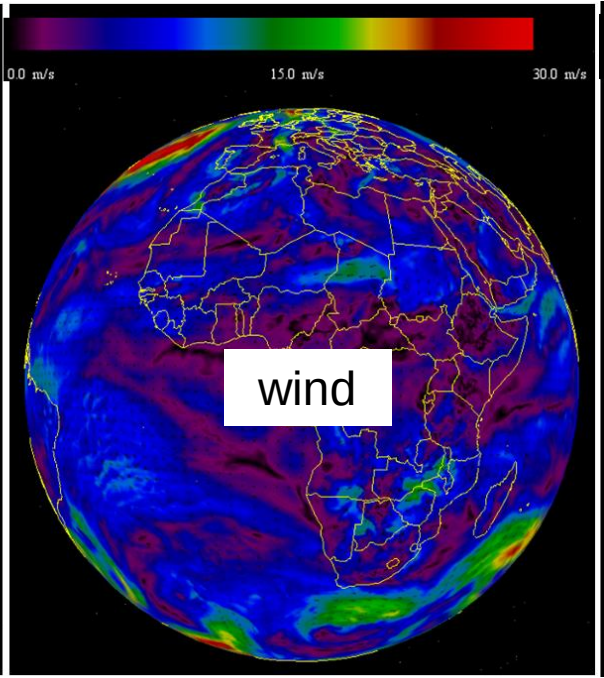
- Many artifacts
  - Near shore
  - Internal waves
  - Ocean current & gradients
  - Upwelling
  - Underwater topography
  - Oil & surfactants
  - Biogenic & mineral oils
  - Marine atmospheric & cellular convexion
  - Mesoscale storms
  - Atmospheric vortex
  - Rainfall

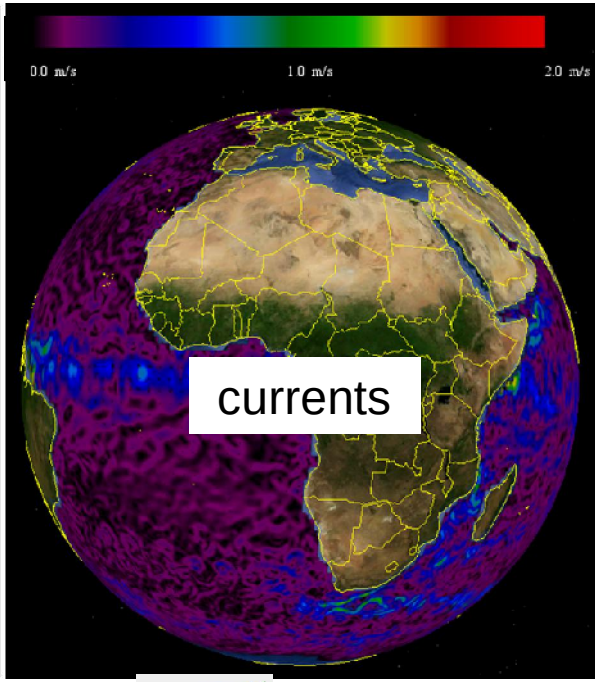


Human photo-interpretation

- Meteorological data and currents
  - Pressure (ECMWF)
  - Wind fields (ECMWF, KNMI, IFREMER)
  - Ocean currents (NOAA)

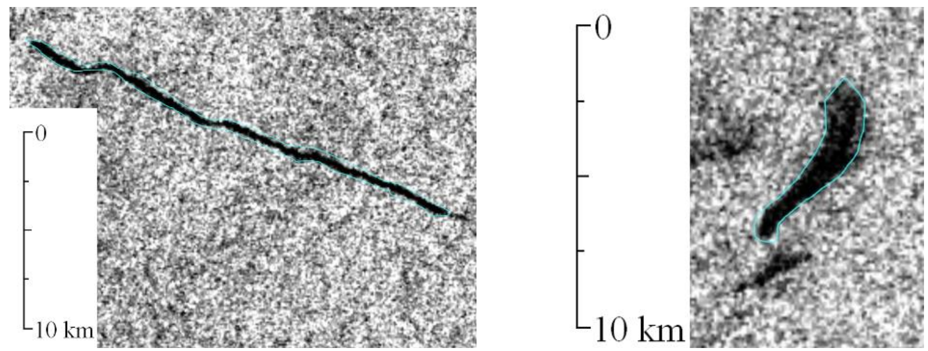


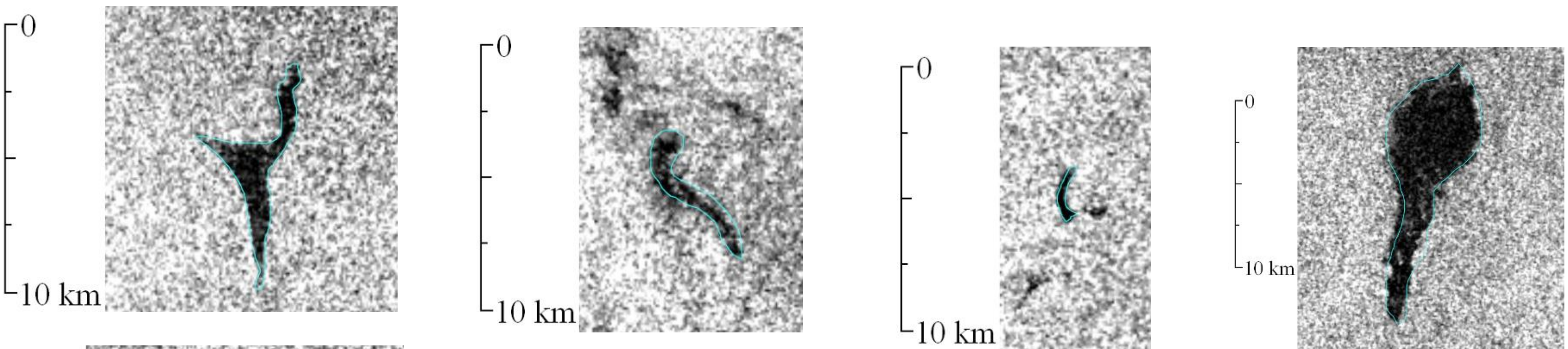


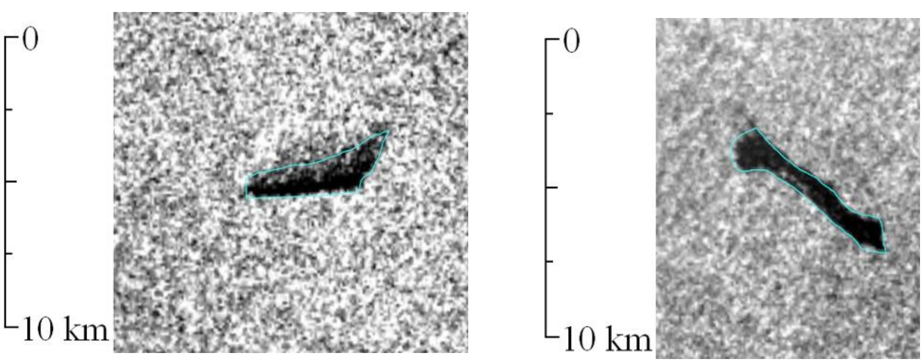


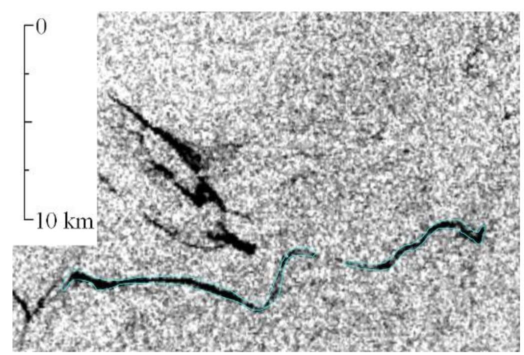
produced by VTEscape™ (VisioTerra)

- Three classes
  - oil spill from ships
  - oil spills from platforms
  - oil seepages (seeps)



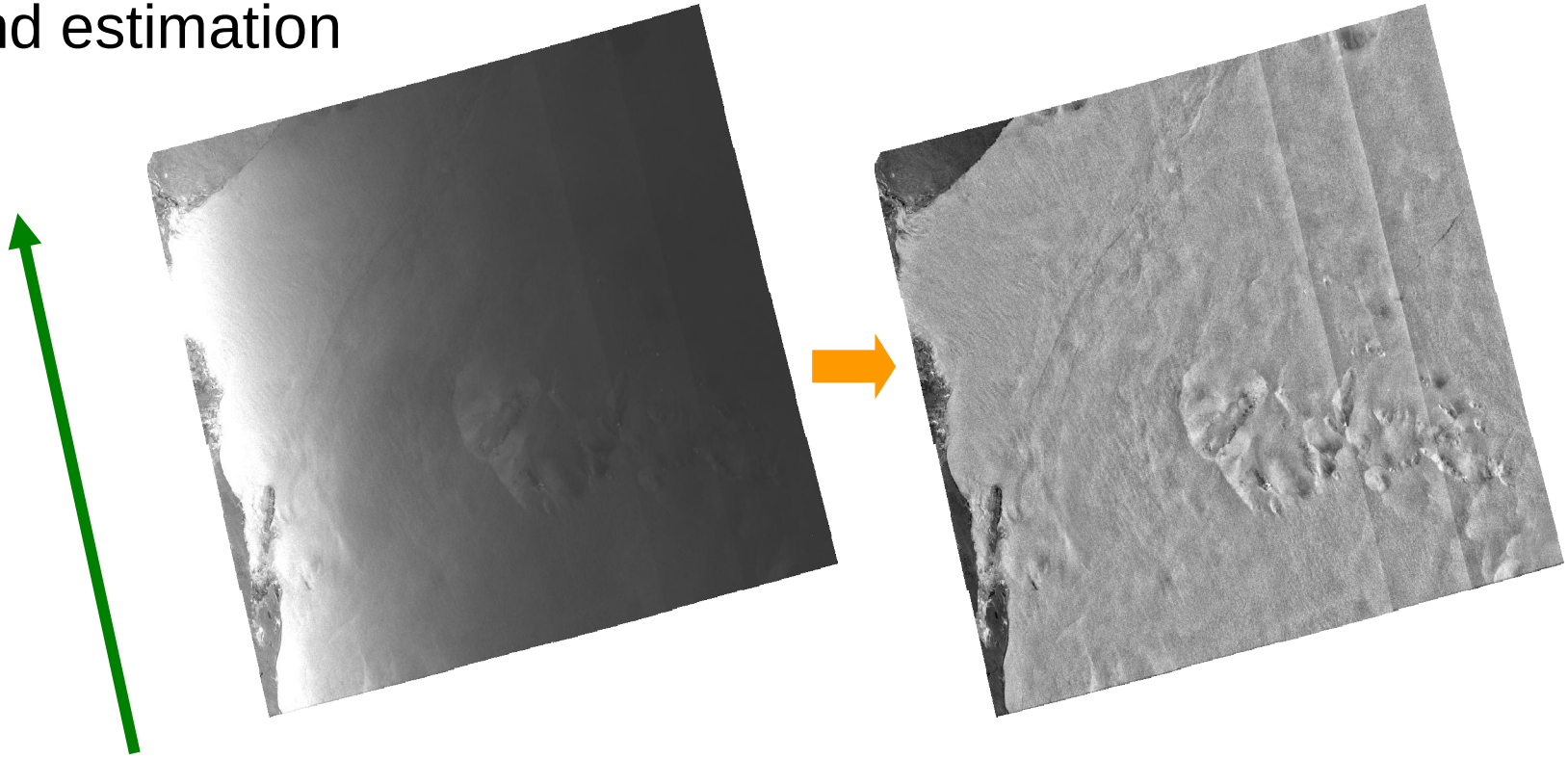






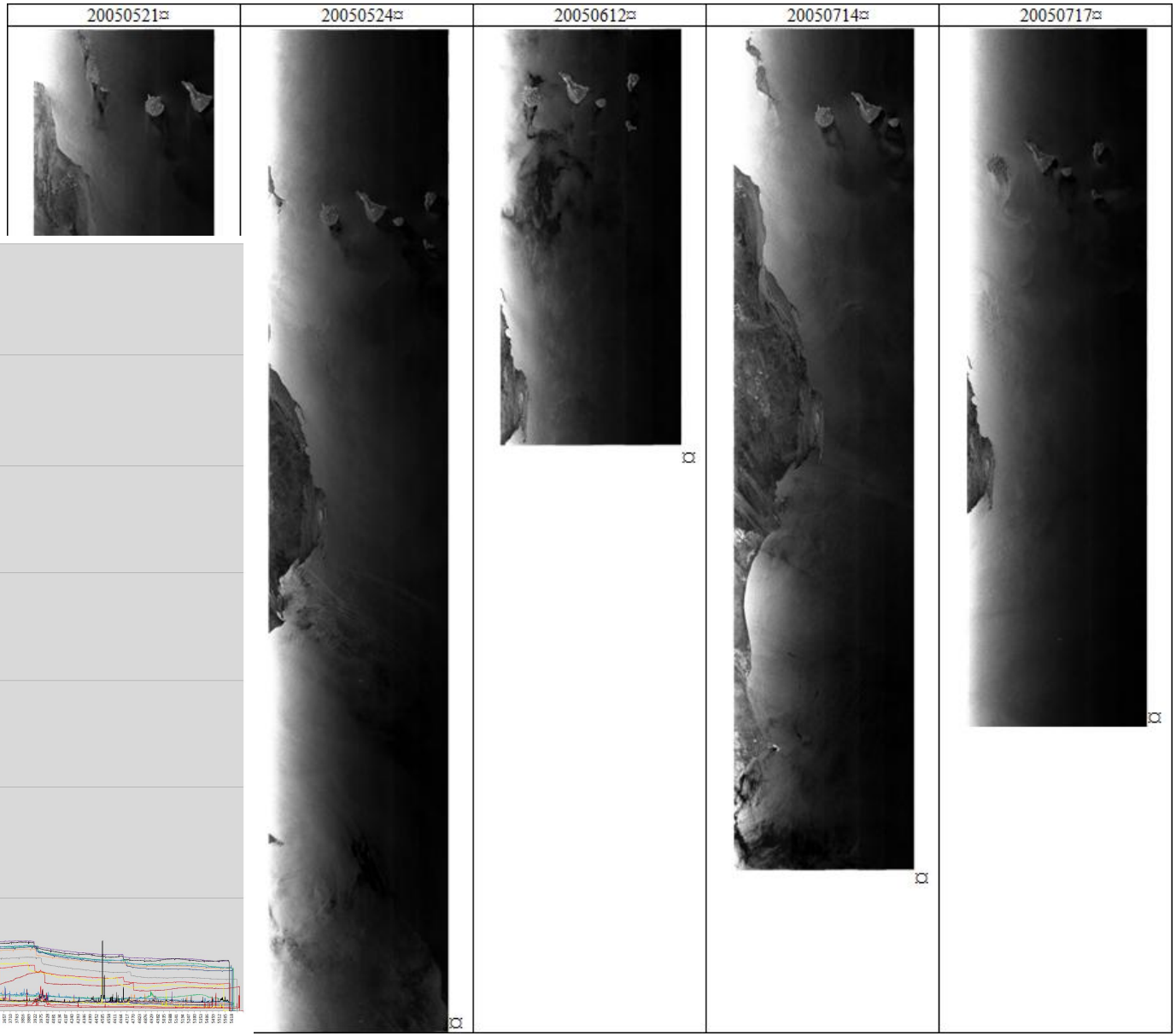
Preprocessing of scenes

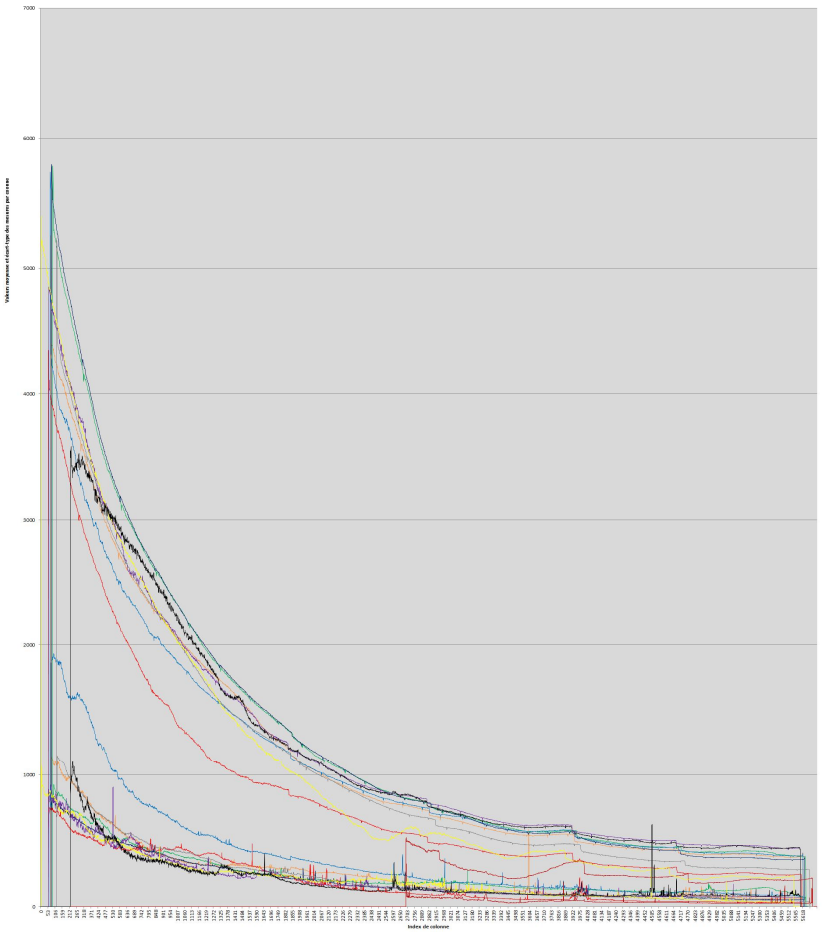
- Local stretching using local statistics
- Radar cross sections modeling
- RMS equalization
- Wind estimation



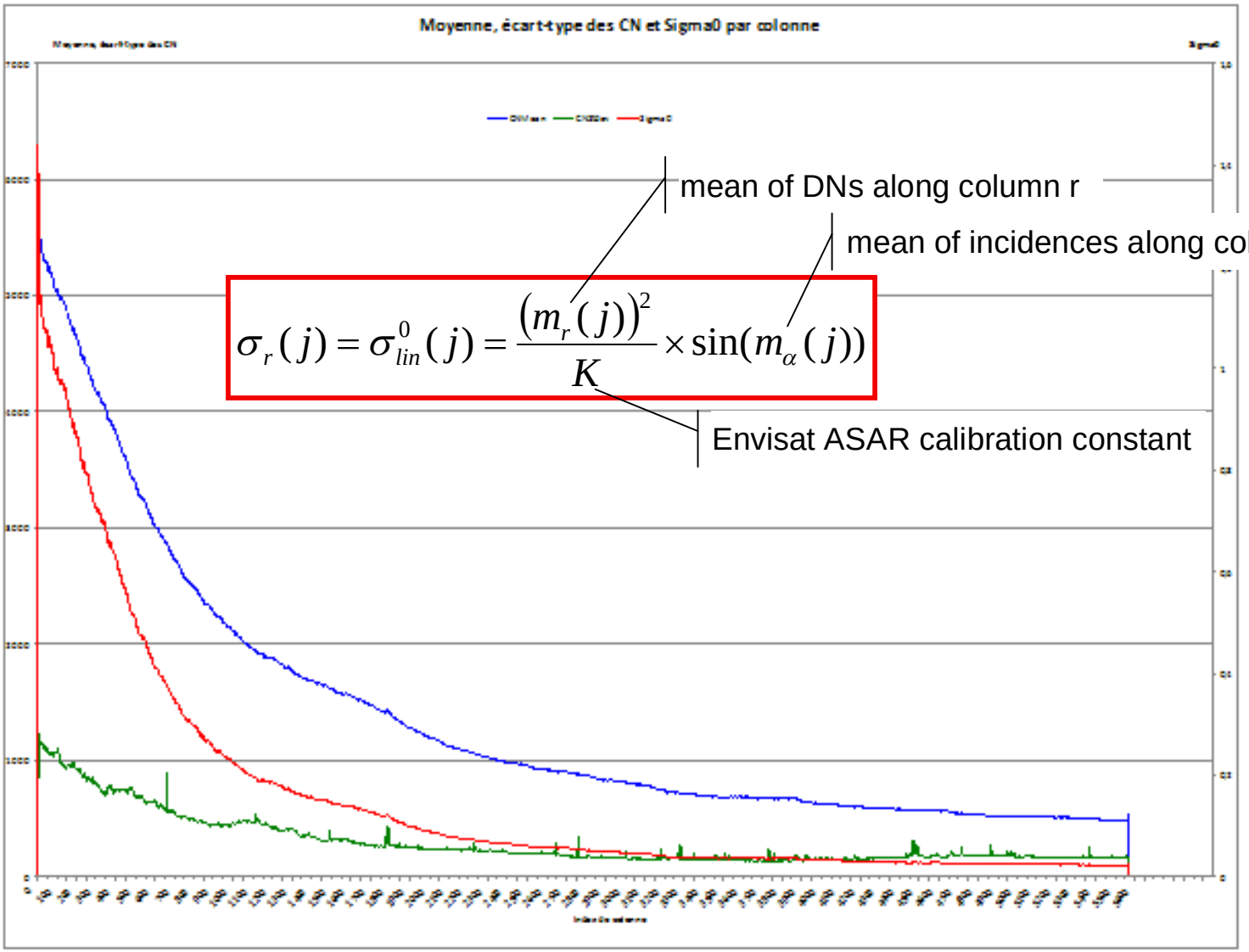
NRCS (Normalized Radar Cross Section) modeling

- Column statistics





From DN to σ_0



mean of DNs along column r

mean of incidences along column j

$$\sigma_r(j) = \sigma^0_{lin}(j) = \frac{(m_r(j))^2}{K} \times \sin(m_\alpha(j))$$

Envisat ASAR calibration constant

The CMOD models (used for scaterrometers)

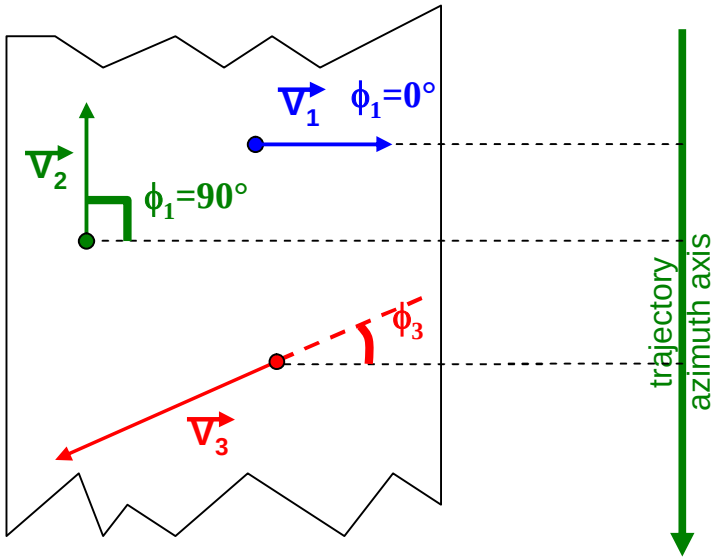
CMOD4

$$\sigma^0_{CMOD4}(V,\phi,\theta) = b_0\left(1 + b_1\cos\phi + b_3\tanh b_2\cos 2\phi\right)^{1.6}$$

incidence of radar pulse over target

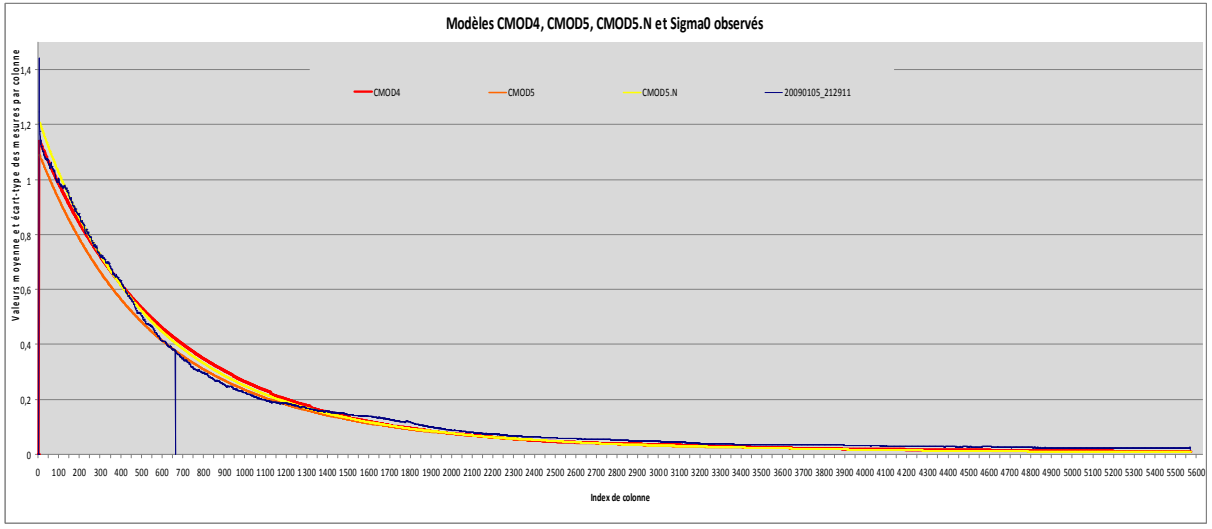
angle between wind and radar pulse

wind modulus



CMOD5 and CMOD5.N

$$\sigma^0_{CMOD5}(V,\phi,\theta) = b_0\left(1 + b_1\cos\phi + b_2\cos 2\phi\right)^{1.6}$$



Estimation minimizing the RMSE

Modeling the NRCS

$$\sigma_r(j) \approx A \times \sigma_M(V, \phi, m_\theta(j))$$

- σ_0 of the model (CMOD4 or CMOD5 or CMOD5.N)
- gain estimated by linear regression
- σ_0 observed

$$E(S_k, M, A, V, \phi) = \sqrt{\frac{1}{\sum_{j=0}^{N-1} \delta(j)} \times \sum_{j=0}^{N-1} \delta(j) \times \left[\sigma_r(j) - A \times \sigma_M(V, \phi, m_\theta(j))\right]^2}$$

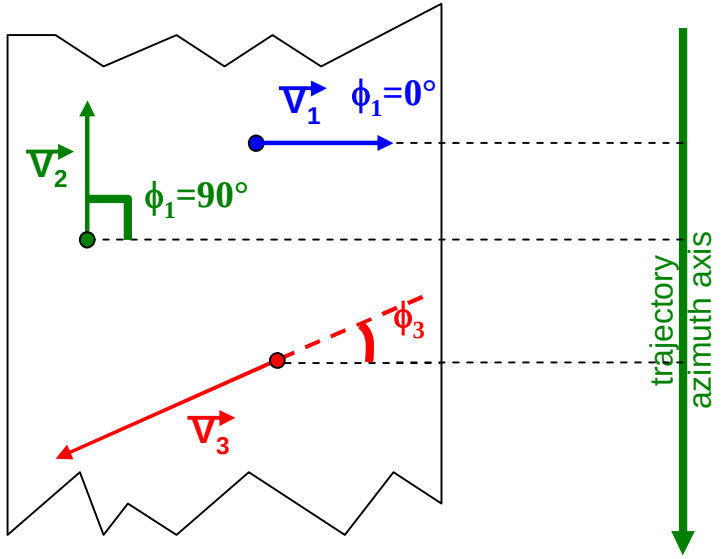
$$\Rightarrow A = \frac{\sum_{j=0}^{N-1} \delta(j) \times \sigma_r(j) \times \sigma_M(V, \phi, m_\theta(j))}{\sum_{j=0}^{N-1} \delta(j) \times \sigma_M(V, \phi, m_\theta(j))^2}$$

Retrieving A assuming a mean value V, ϕ

Solution with mean wind – proposed by Bertrand CHAPRON (IFREMER)

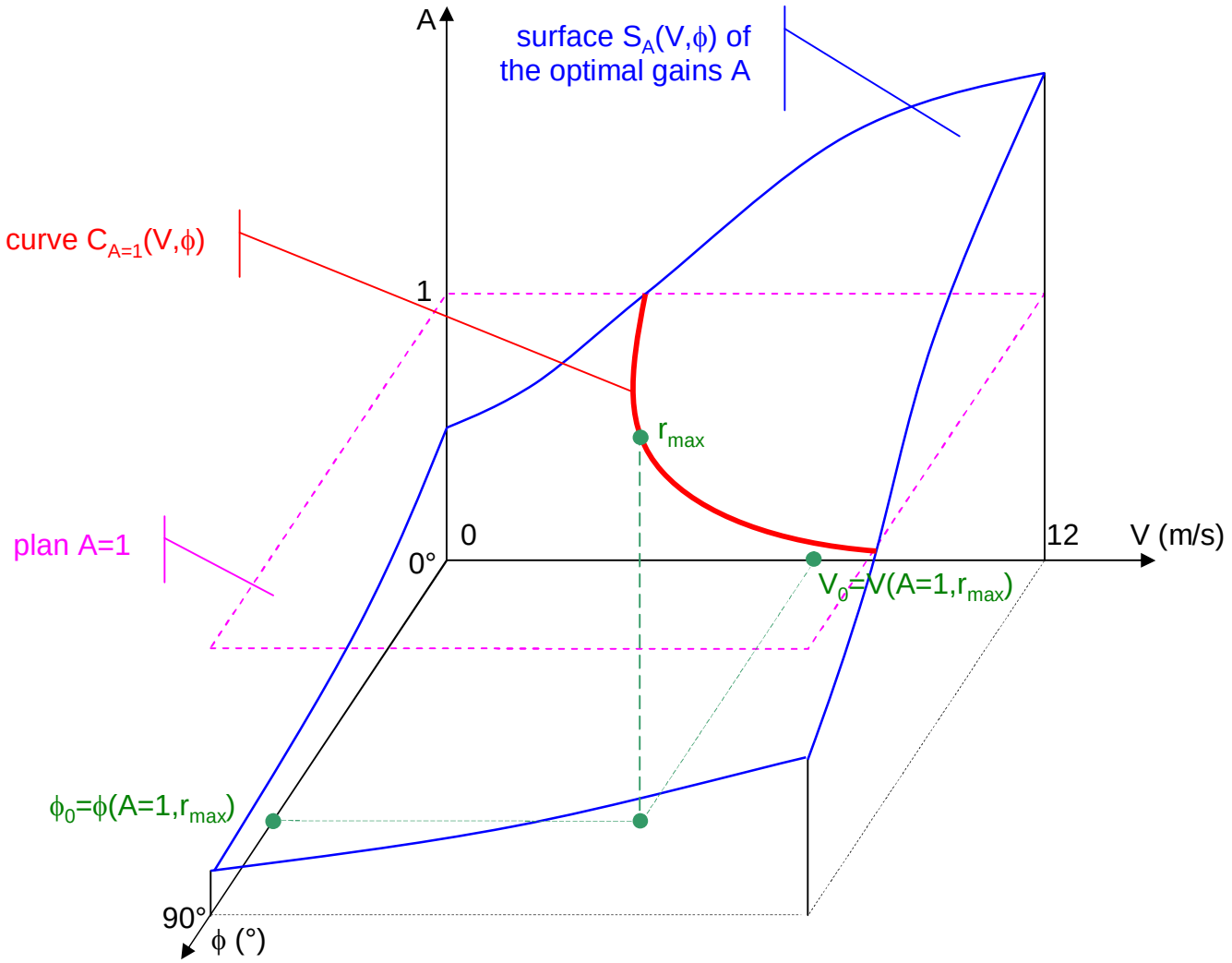
V = 7 m/s
ϕ = 45°

⇒ We retrieve **V x cos(ϕ)**



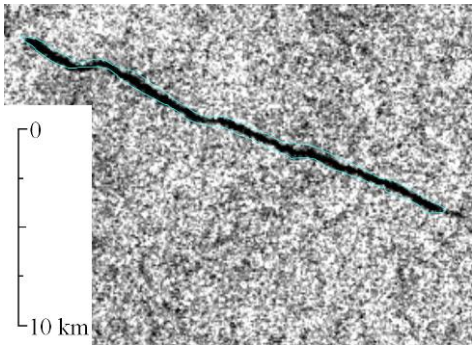
Retrieving A and V, ϕ

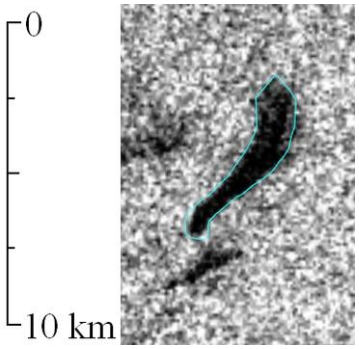
Exhaustive solution – proposed by VisioTerra

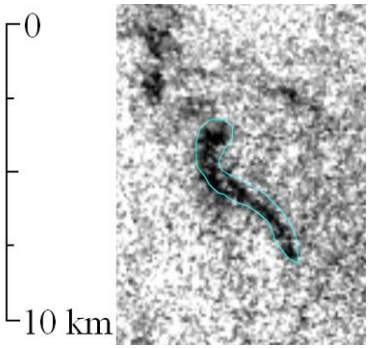


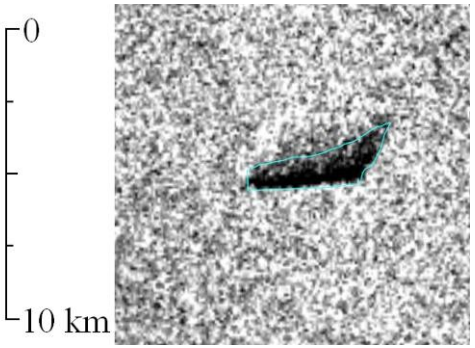
Features extraction

- Connex components determination
  - Hysteresis thresholding
  - Components aggregation
- Connex components measurements
  - Geometry features - area, compacity, linearity, holes frequency…
  - Radiometry features - mean, standard deviation, relative contrast…
  - Spatial frequency - Occurrence image





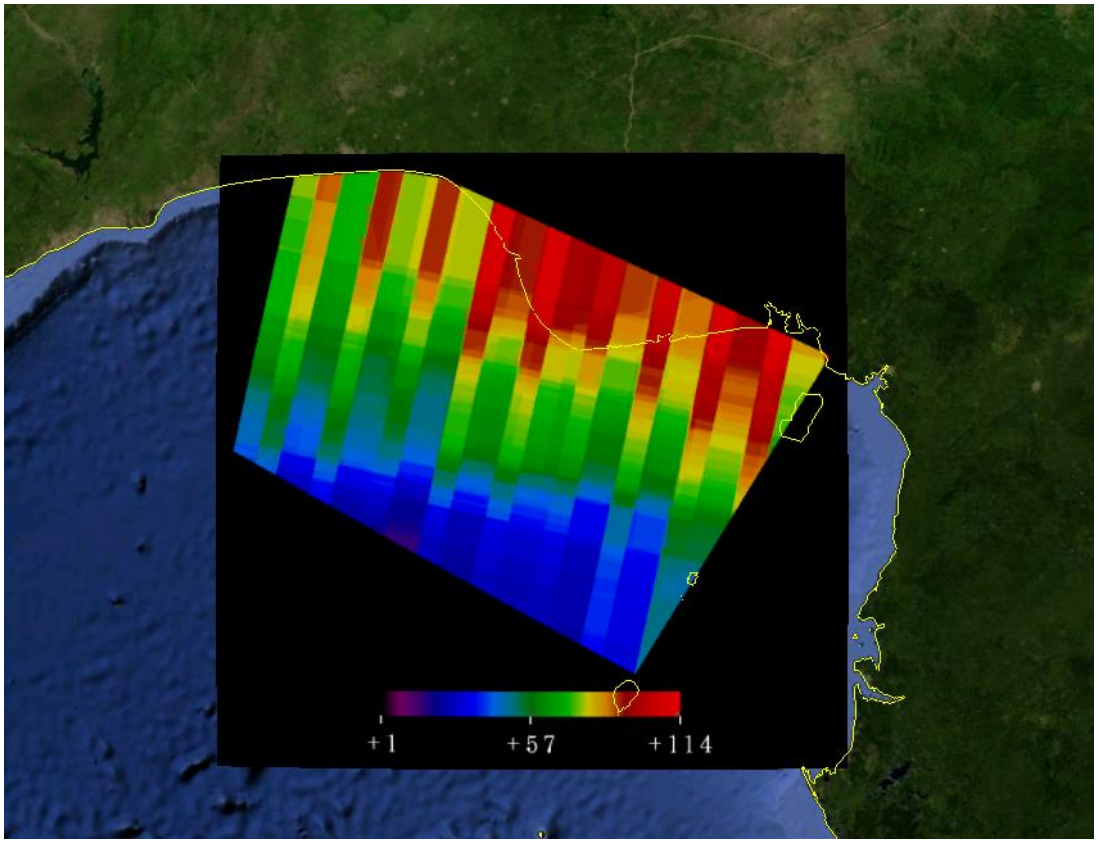




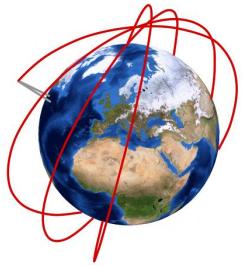
Classification

- Classification
  - Three classes: -oil spill from boats, -oil spills from platforms
  - Training sets and confusion matrix
  - Cartographic production

- Occurrences and frequencies

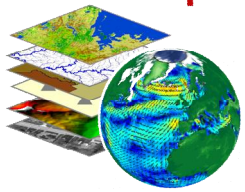


Conclusions



- Collaboration VisioTerra - University - ESA

VTEscape

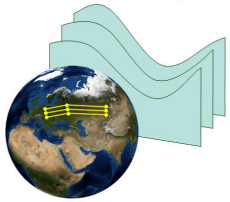


- Development of new algorithms and softwares
  - wind direction and modulus
  - morphological (object oriented) classification
  - Occurrence and frequencies

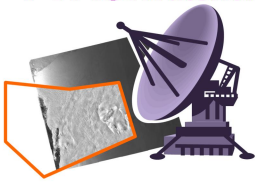
VT Tile Grabber

- Dedicated to the environment

VT Geomorpho



VT AOI Watcher



- Production of maps
  - oil routes (yearly since 1991)
  - oil spill pollutions from platforms (archive and real-time monitoring)
  - oil seeps frequencies (seeps DB)

Thank you