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

Observing the Earth with visible and radar
Why oil is appearing black?
All black objects are not always oil!
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
Many artifacts
- Near shore
- Internal waves
- Ocean current & gradients
- Upwelling
- Underwater topography
- Oil & surfactants
- Biogenic & mineral oils
- Marine atmospheric & cellular convection
- Mesoscale storms
- Atmospheric vortex
- Rainfall
➢ 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

![Images of radar cross sections for different dates]
From DN to $\sigma_0$

\[ \sigma_r(j) = \sigma_{\text{lin}}^0(j) = \frac{(m_r(j))^2}{K} \times \sin(m_\alpha(j)) \]

- Mean of DNs along column $r$.
- Mean of incidences along column $j$.
- Envisat ASAR calibration constant.
The CMOD models (used for scatterometers)

**CMOD4**

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

- incidence of radar pulse over target
- angle between wind and radar pulse
- wind modulus

**CMOD5 and CMOD5.N**

\[
\sigma_{CMOD5}^0 (V, \phi, \theta) = b_0 \left( 1 + b_1 \cos \theta + b_2 \cos 2\phi \right)^{1.6}
\]
Estimation minimizing the RMSE

Modeling the NRCS

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

\[ \sigma_0 \text{ of the model (CMOD4 or CMOD5 or CMOD5.N)} \]

\[ \sigma_0 \text{ observed} \]

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

\[ \Rightarrow A = \frac{\sum_{j=0}^{N-1} \delta(j) \times \sigma_r (j) \times \sigma_M (V, \phi, m_\theta (j))}{\sum_{j=0}^{N-1} \delta(j) \times \sigma_M (V, \phi, m_\theta (j))^2} \]
Retrieving $A$ assuming a mean value $V$, $\phi$

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

$V = 7 \text{ m/s}$
$\phi = 45^\circ$

$\Rightarrow$ We retrieve $V \times \cos(\phi)$
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

- 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

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

- Dedicated to the environment

- 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