Space-based information applications related to climate change monitoring in Morocco

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Current situation: trend of Moroccan climate towards a general warming
Significant decrease of cool days

→ Clear decrease of cool days at national level : (~25 days during 45 years)

→ Low increase of hot days
Significant Reduction of Precipitation

Trend towards reduced rainfall and drying mainly at the end of the rainy season on the major part of the country

Positive trends in the maximum duration of drought and high interannual variability since 1995

Intensification of extreme events: Thunderstorms, droughts, floods…
Current situation of Moroccan climate: migration to the arid and semi-arid

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Source: Direction de la Météorologie Nationale
Future Scenarios of Climate Change in Morocco

Change in seasonal mean temperatures
Future Scenarios of Climate Change in Morocco

Change in seasonal mean Precipitations
Remote sensing applications in the diagnosis of impacts of climate change in Morocco

Several fields related directly or indirectly to climate change (CC), are analyzed and evaluated using Space Observation Techniques, mainly in sectors suffering the impacts of climate change:

Agriculture, droughts, forestry, marine resources and coastal areas, water resources...

Three components of climate Change are addressed:

- Contribution to the national inventory of the GHG emissions
- Characterization and Evaluation of the vulnerability of sectors impacted by CC
- Assessment of the climate Change impacts
Mapping land cover and monitoring land use changes at various space and time scales

- Land cover influences the exchange of mass and energy between the surface and the atmosphere (energy, carbon dioxide and other GHG emissions) and therefore influences the temperature and climate.

- Changes in types of land use, particularly affecting forest and agriculture in terms of area and biomass, play an important role in GHG emissions.

- Providing data to quantify and update biomass necessary for the updating of national inventory of GHG.
Mapping land cover and monitoring land use changes at various space and time scales

Regional scale
(region of Agadir)
Monitoring of global vegetation conditions and changes

Annual vegetation cover produced by the NDVI method (NOAA / AVHRR)

2 objectives related to CC:
1. Calculation of carbon absorption by plants (contribution to the setting up and the updating of the National inventory of GHG)

2. Assessment of CC Impacts on the vegetation conditions and soil degradation caused by the decrease or absence of Precipitation

- Operational monitoring system producing maps describing weekly, monthly and seasonal changes
- Providing a comprehensive picture of the development of different types of vegetation

The assessing of CC impacts on vegetation conditions and changes detection are done on an annual basis
Global monitoring of vegetation conditions and changes

Vegetation Change Map

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Implementation of a Drought Early Warning System

Justification:
1. Importance of agriculture in the Moroccan economy
2. High interannual variability of precipitations
3. High frequency of dry years

The DEWS is based on a combination of various operational indicators derived from, EO and Meteorological data (NOAA_AVHRR):

- Standardized Vegetation Index (SVI)
- Vegetation Condition Index (VCI)
- Temperature Compensating Index (TCI)
- Index related to the health condition of vegetation (VH)
- Standardized Precipitation Index (SPI)
- Palmer Drought Severity Index (PDSI)

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Implementation of a Drought Early Warning System

Indicators

VCI

TCI

\[ VH = 0.5 \times \text{VCI} + 0.5 \times \text{TCI} \]

Décembre, Mars 2012
Implementation of a Drought Early Warning System

Indicators

VH
Mars 2012
Decade3

VT<40% stress (Kogan)

Légende

- Proche des valeurs minimales (20%)
- Entre 20 et 40%
- Entre 40 et 60%
- Entre 60 et 80%
- Proche des valeurs maximales
- Nuages (ou neige)
Implementation of a Drought Early Warning System

Indicators

Légende
- Inférieur à la moyenne
- Légèrement inférieur à la moyenne
- Légèrement supérieur à la moyenne
- Supérieur à la moyenne
- Nuage (ou neige)
Implementation of a Drought Early Warning System

Indicators

PDSI

Légende

PDSI

- Extrêmement sec
- Très sévèrement sec
- Sévèrement sec
- Moderément sec
- Légèrement sec
- Début de sécheresse
- Normal
- Début d'une période humide
- Légèrement humide
- Modérément humide
- Sévèrement humide
- Extrêmement humide
- Pas de données

SPI

- Très humide
- Humide
- Normal
- Sec
- Très sec
- No Data
Desertification monitoring and assessment of degraded lands

- Deforestation: 33,000 ha/year

- Degradation of rangelands: 8,3 M ha

- Over Pasturage: more than 23% of the capacity rangelands

- Hydric erosion: Threat 2/3 of cropland

- Stalinization: affects 37,000 hectares of irrigated lands

+ Climate changes effects

Objectives:

- Production indicators of vulnerability and desertification sensitivity maps

- Prevention of environmental degradation caused by drought and development of adaptation strategies to adapt to the impacts of drought
Synthetic map of desertification risk (1987-2009)

- Desertic areas or very high risk
- High Desertification risk
- Moderate Desertification risk
- Low Desertification risk
- Stable areas

In situ Data

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Annual map of hydric conditions.
Satellite Forest Monitoring

-Moroccan forest area: 9M ha (12% of territory)

- High Vulnerability of Moroccan forest areas facing CC and trend of Moroccan climate towards aridity: reduced rainfall, persistent of drought:
  - More than 30,000 ha/year of forest areas are degraded
  - Multiplication of Forest fires

- Establishment of the national forest inventory
- Systematic Updating of forest maps at various scales
Forest Monitoring

Forest maps

Regional scale

a part of Atlas Mountains

Oriental
Monitoring of Forest areas

Ain Beni Mathar

- Cèdre
- Pin
- Genévrier
- Thuya
- Sapin
- Autres résineux
- Arganier
- Arganier
- Autres feuillus
- Cèdre en mélange
- Pin en mélange
- Genévrier en mélange
- Thuya en mélange
- Sapin en mélange
- Autres résineux en mélange
- Chêne liège en mélange
- Chêne vert en mélange
- Chêne zeen en mélange
- Arganier en mélange
- Autres feuillus en mélange
- Matorral
- Alfa
- Reboisements résineux
- Reboisements feuillus
- Terrains non boisés
Detection and monitoring of forest changes

Change map: 1997-2008

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CC has a significant impact on the water shortage, mainly in arid and semi-arid regions of Morocco.

The assessing of this deficit and its variations is a crucial information to better manage this resource and provide adaptation scenarios.

Development of an integrated approach to manage water resources in some hydraulic basins based on EO and In situ data.
Managing water resources

Forecasting changes in the depth of the water layer in 2020

Variation 2005-2020

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50

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New Project:
LDAS (Land Data Assimilation System)

Regional Project: Morocco, Tunisia, Egypt, Jordan and Lebanon, Financed by WB and supported by NASA

Objectif:

Strengthen national capacities to assess climate change impacts on water conditions:

- Assess climate change impacts on the water sector experienced during the last decades
- Characterize the current national water potentialities more accurately
- Develop future scenarios for climate change impacts on water demand based on inputs from downscaling climatic global models (projections) to identify vulnerable areas
- Flood forecast in the small watersheds
- Flood monitoring at high temporal and spatial resolution
Monitoring and analysis of CC impacts in marine and coastal areas

Mapping of dynamic height of the sea and detection of sea level anomalies

Altimetry data: TOPEX and POSEÏDON

Sea level rise
Monitoring and analysis CC impacts of CC in marine and coastal areas

Anomalies Maps of Surface of Sea Level (SLA)

1993

1994

1995

Cm

-1.3
-1.2
-1.1
-1.0
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
Monitoring of coastal dynamics and evaluation of coastline erosion

Coastal zones are the most vulnerable sectors suffering the CC impacts, particularly because of high sea level rise.

**Goal**: Monitoring the evolution of coastal systems along the Moroccan coast and producing maps of spatial and temporal variations of the coastline

- Quantification of the coastline dynamic intensity and delimitation coastal zones suffering degradation: fast erosion sectors, thrust sectors...

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</table>
Monitoring of coastal dynamics and evaluation of coastline decline

Examples on Mediterranean Sea

Tanger
Detection and monitoring of upwelling

- Important phenomenon for the Moroccan fisheries
- Phenomenon hydro climatic largely influenced by changes in climatic conditions (winds fluctuations)
- Development of operational monitoring products of upwelling (SST, Chlorophyll a, upwelling index) to Support management of fisheries and stock forecasting
Detection and monitoring of upwelling

Interannual evolution Upwelling index along Moroccan coasts
Detection and monitoring of upwelling

Example of Relationship between Climate (Wind), upwelling and fisheries (1996 - 1997)

(source: Fridjof Nansen cruises)

Anomalies de l'indice d'Upwelling zone: 21-35 °N
Example of adaptation to CC impacts:
Development of system of pre selection aquaculture sites

Implementation of a GIS application for the development of aquaculture potential of the Moroccan coasts

Semi Closed Lagoon Site

Offshore Site

Open Bay

Dakhla
Development of Geographic Database

- In situ measures
- Climate data
  - hydrodynamic model results
  - Vector Data
  - Topographic and marine maps
  - Satellite Products

| DATE | HEURE | PROF. | MLONG | MLAT | MNTS |
|------|-------|-------|-------|------|------|-------|
| 12.1 | 13.4  | 0     | 36.4  | 0    | 3.35 | 0.0003 |
| 15.1 | 13.4  | 0     | 36.4  | 3.4  | 25.99 | 0.0003 |
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| 14.6 | 36.5  | 0.2   | 1.8666| 13.5051| 10.8889 |
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| 16.6 | 36.5  | 0.1   | 0.9033| 15.0769| 7     |
| 15.4 | 36.5  | 0.2   | 0.4   | 10   | 3.8889 |
| 15.4 | 36.5  | 0     | 0.4667| 18.86 | 4.8889 |

Socio-economic data

- Climate data
Spatial Analysis Model for pre selection of aquaculture areas

Selection criteria species

- Exploitation space maritime
- Soil deposits
- Pollution Sources
- Closed infrastructures
...

Site Environment

Milieu Parameters
- Hydro.
- SS
- Temp.
- Bottom Type
- Bathy.
...

favorable area for aquaculture

Biological and Chemical needs
- Salinity
- Chl-a
- O2
- Nitrate
- Nitrite
- Hp
...

Breeding techniques

- Floating cages
- Fixed cages
- Breeding on table
- Suspended Breeding
...

- Floating cages
- Fixed cages
- Breeding on table
- Suspended Breeding
...
According to the criteria selected, and the application of potentiality threshold for each criterion, of the potential areas for the aquaculture by specie and breeding technique are identified.
How can Space-based to address Climate Change questions In Morocco?

WHAT?

Developing an operational CC science activity using space applications to:

- Characterize current, improve understanding current and prediction CC, by integrating ocean/atmosphere interaction component in the region (natural variability, global warming...)

- Better understand and predict local climate to prepare adequate local adaptation strategies and ensuring local sustainable development

- Contribute to efforts to reduce GHG emissions, measure and identify the opportunities for emission reduction that are realizable

- Assess accurately vulnerabilities and current and futures CC impacts in sensitive sectors: hydrology, agriculture, marine resources, coastal zones, forestry, meteorological risks ...

- Assess the potential for adaptation
How can Space-based address Climate Change questions In Morocco?

How?

- Performing adequate methodologies to process and interpret space data and combination with ground-based measures when addressing CC questions

- Strengthening of national capacity building: training, stages, ...

- Facilitating access to and sharing adequate available Earth Observations data and derived products

- Setting up an national /regional systematic observing Networks and strengthening the space observation system

- Identifying, funding and implementing an integrate and relevant regional project treating all questions of CC

- Strengthening the international, regional and national cooperation regarding the use of space data in CC
THANK YOU