



المركز الملكي للاستشعار البعدي الفضائي

CENTRE ROYAL DE TELEDETECTION SPATIALE

**United Nations/Indonesia : International Conference on
Integrated Space Technology Applications to Climate Change**

2 - 4 September 2013, Jakarta, Indonesia

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

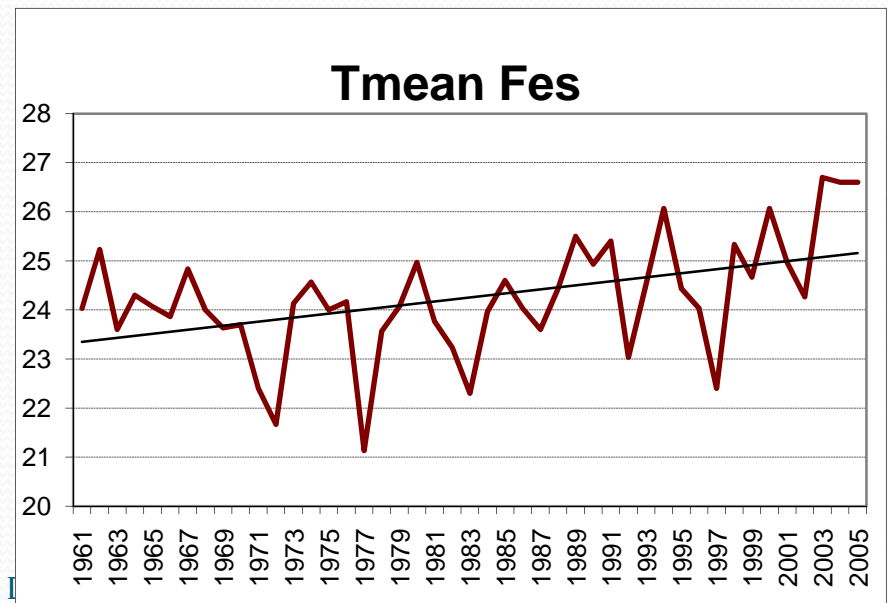
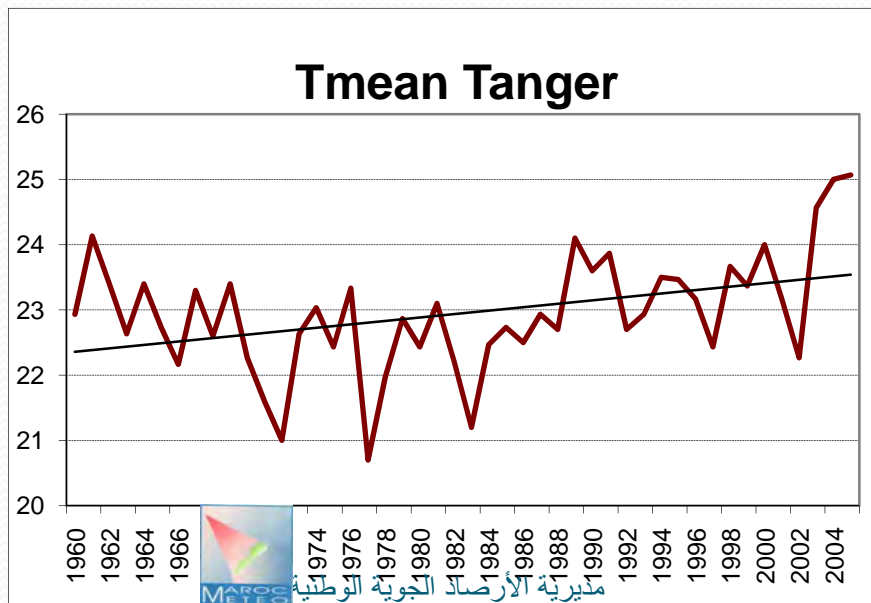
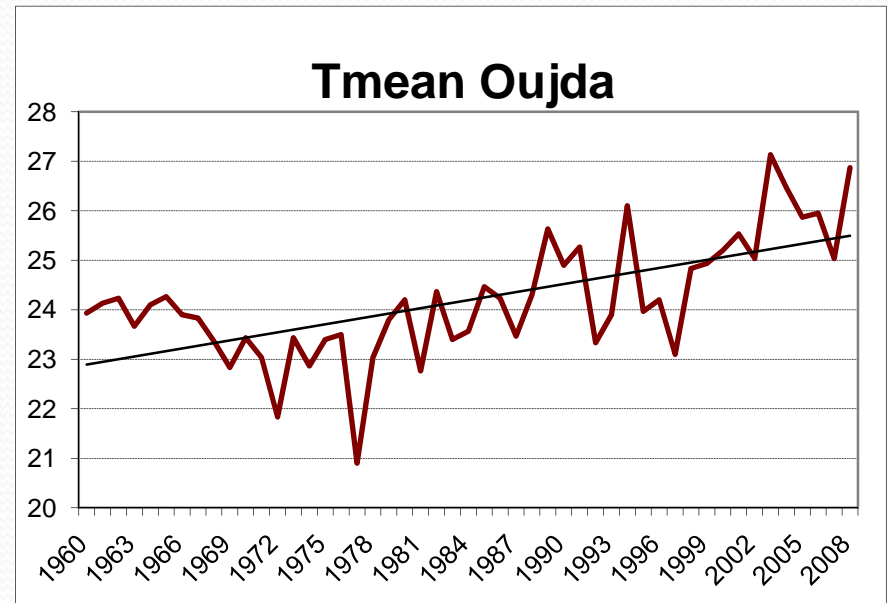
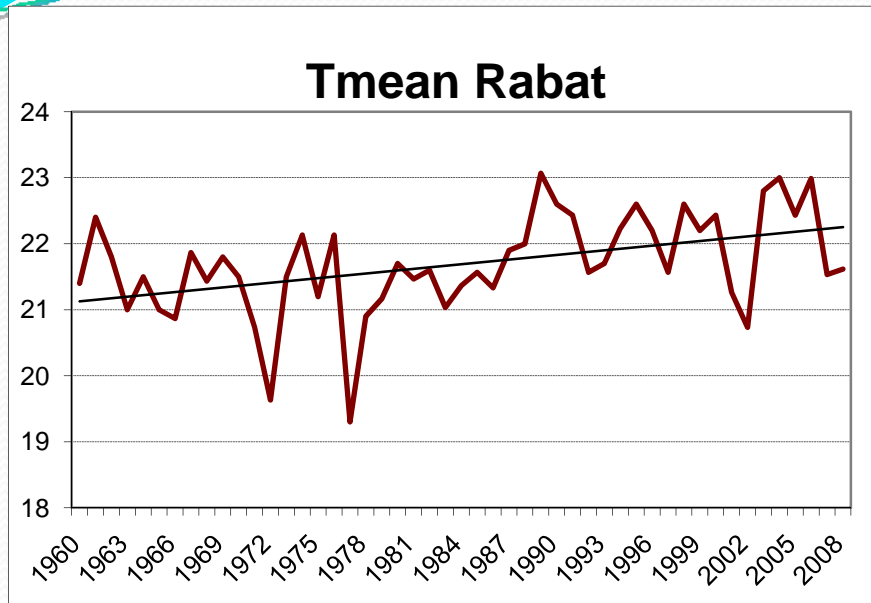
Abderrahman ATILLAH

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Adresse : Secteur 21, Angle Av. Allal El Fassi et Av. Assanawbar - Hay Riad, Rabat (Morocco) –

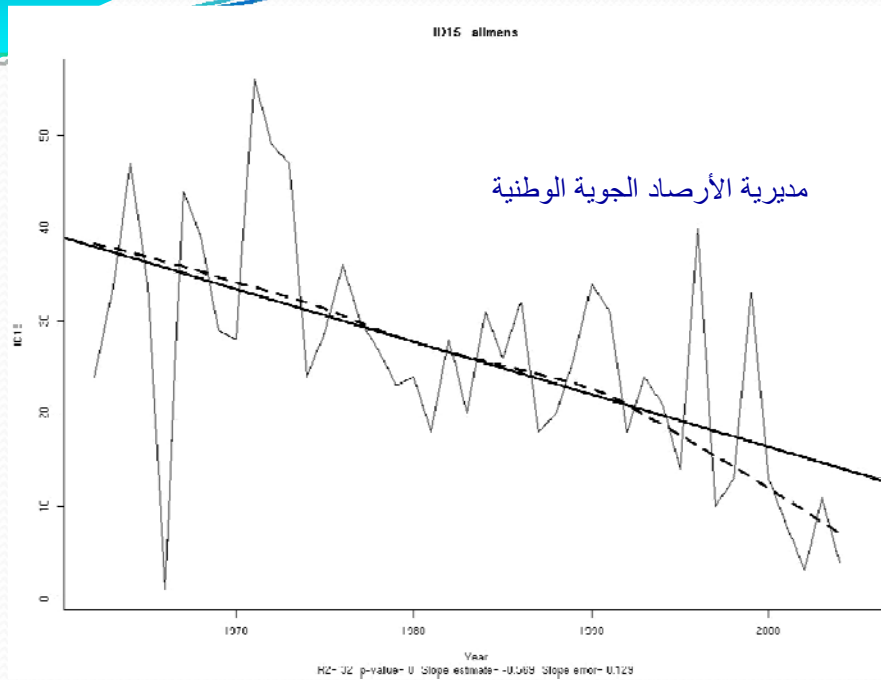
Tel. : 037-71-54-48/98 – Fax : 037-71-14-35 Site : www.crts.gov.ma,

Current situation: trend of Moroccan climate towards a general warming

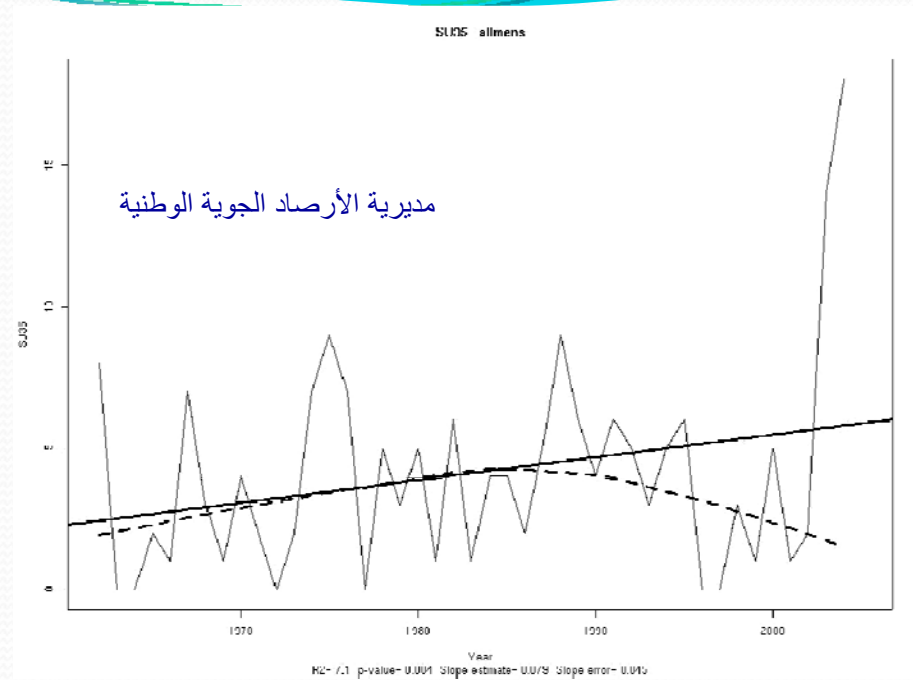


المرکز الوطني للأرصاد الجوية
MTC

Significant decrease of cool days



Total annuel de jours frais (Maroc)



Total annuel de jours chauds (Maroc)

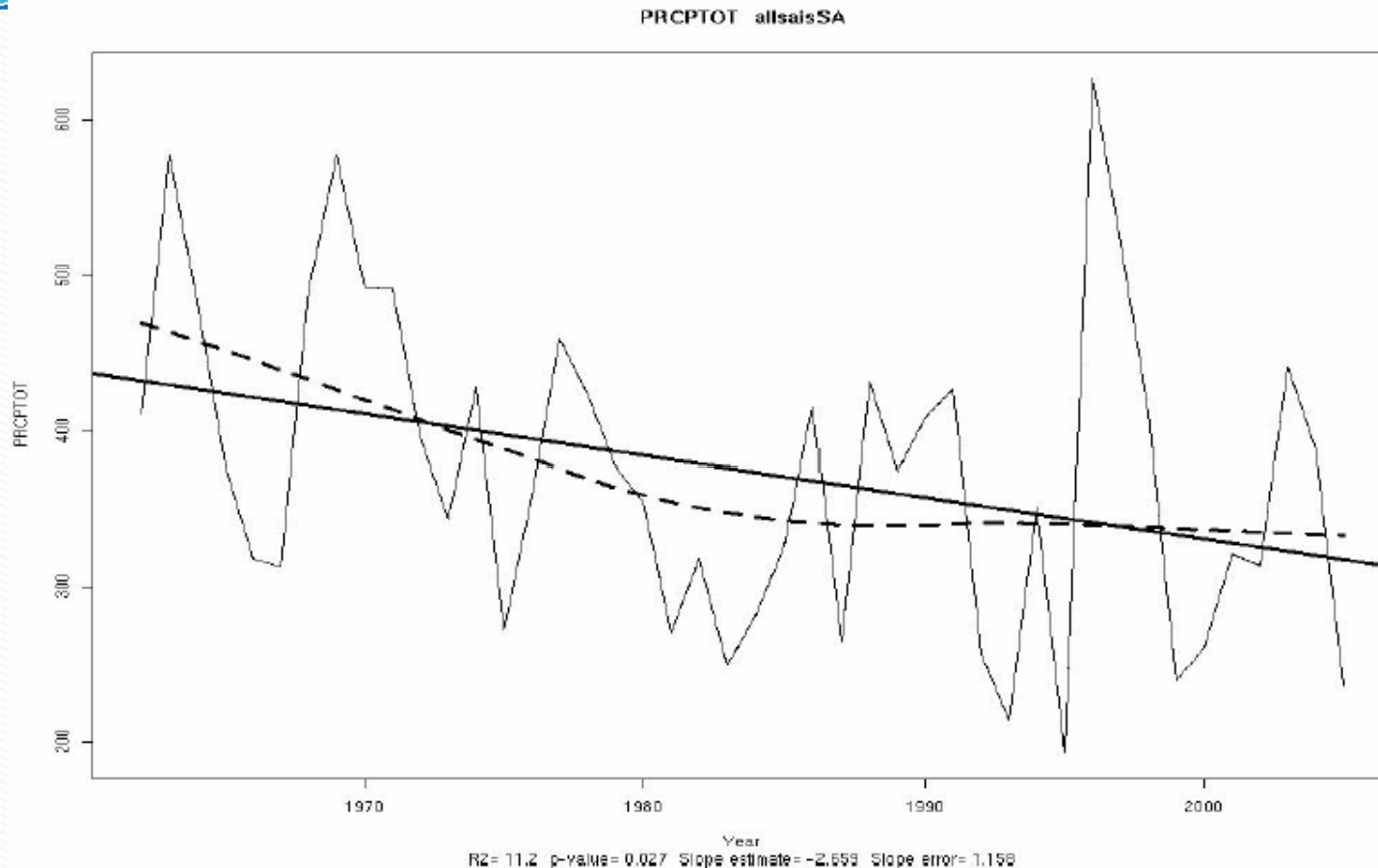
→ Clear decrease of cool days at national level : (- 25 days during 45 years)

→ Low increase of hot days

DMN



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

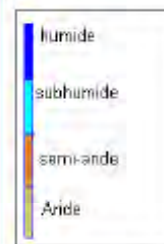
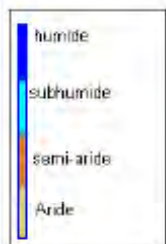
Positive trends in the maximum duration of drought and high interannual variability since 1995

Intensification of extreme events: Thunderstorms, droughts, floods...

DMN



Current situation of Moroccan climate: migration to the arid and semi arid



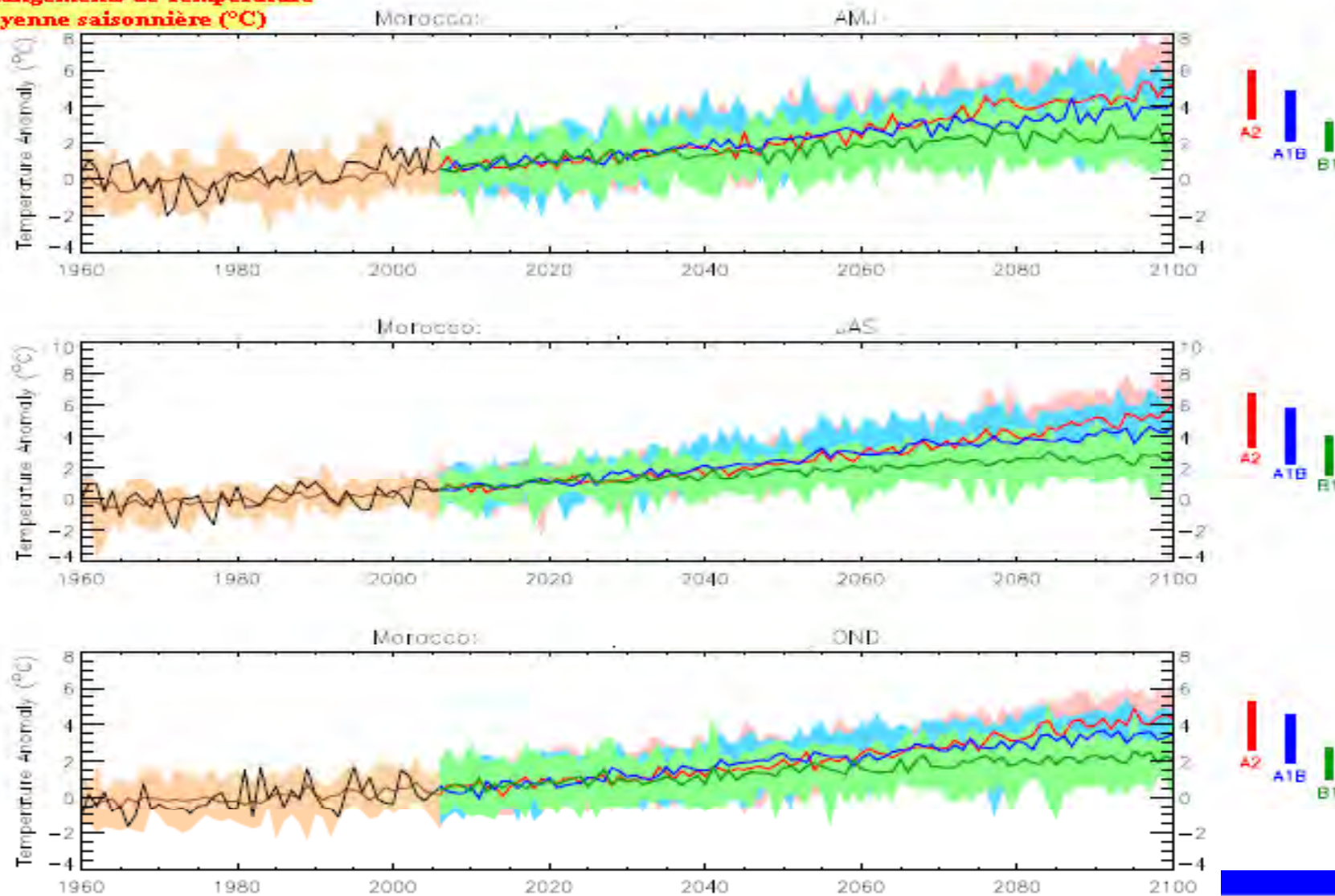
Stations	Idm 61_85	climat correspondent	Idm 86_2005	climat correspondent
TANGER	26.93	Semi-humide	25.29	Semi-humide
OUJDA	12.95	Semi-aride	9.49	Aride
TAZA	25.11	Semi-humide	18.22	Semi-aride
KENITRA	21.31	Semi-humide	10.17	Semi-aride
RABAT-SALE	20.93	Semi-humide	18.03	Semi-aride
FES-SAIS	19.49	Semi-aride	16.19	Semi-aride
MEKNES	21.97	Semi-humide	17.07	Semi-aride
CASA-ANFA	15.74	Semi-aride	13.78	Semi-aride
IFRANE	47.71	Humide	41.26	Humide
SAFI	13.51	Semi-aride	13.12	Semi-aride
MIDELT	9.07	Aride	6.78	Aride
MARRAKECH	8.36	Aride	7.29	Aride
AGADIR	9.04	Aride	8.71	Aride
OUARZAZATE	3.56	Aride	4.36	Aride

Source : Direction de
la Météorologie
Nationale

Future Scenarios of Climate Change in Morocco

Change in seasonal mean temperatures

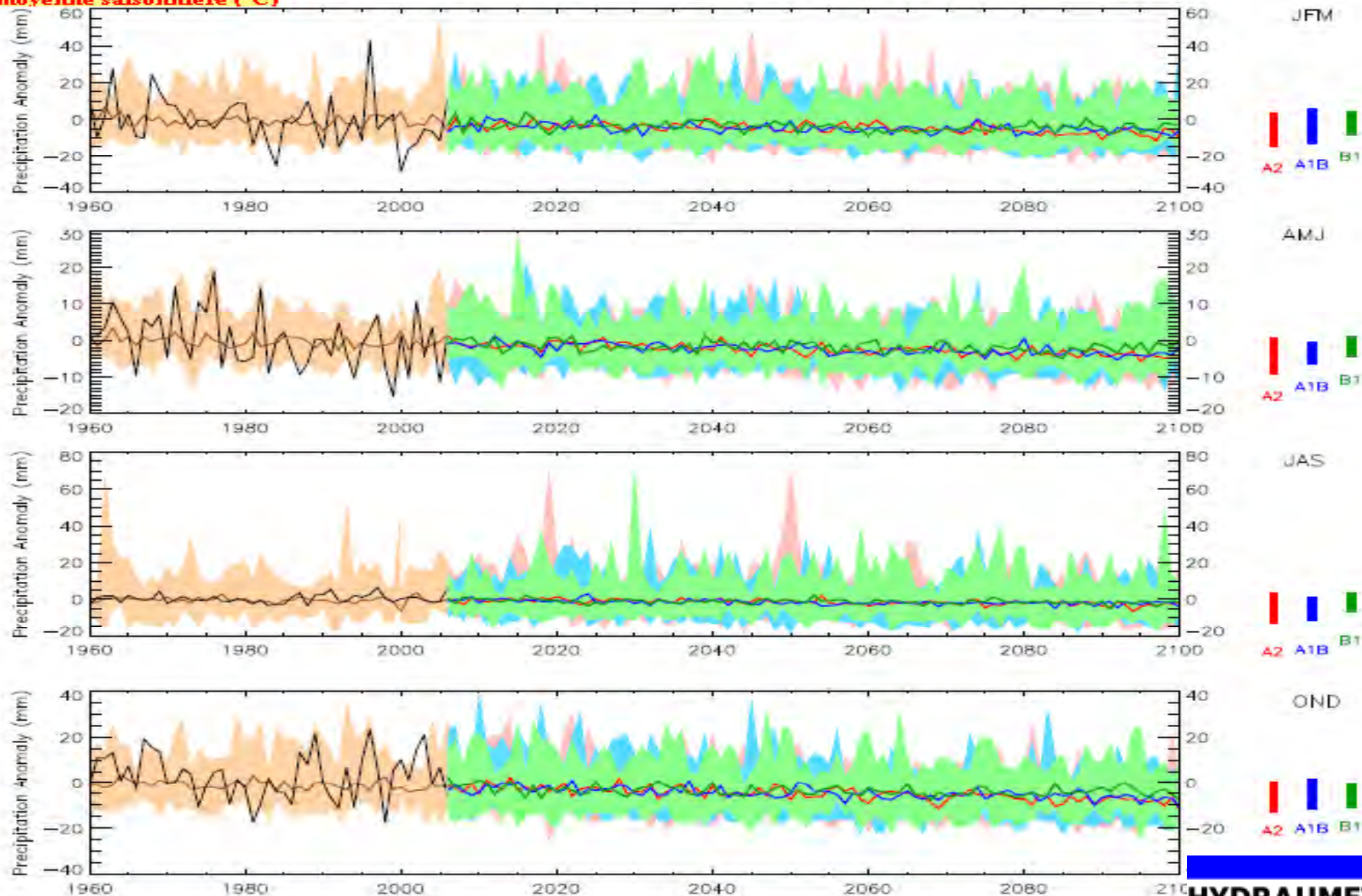
Changements de Température
moyenne saisonnière (°C)



Future Scenarios of Climate Change in Morocco

Change in seasonal mean Precipitations

Changements de Précipitations
moyenne saisonnière (°C)



Remote sensing applications in the diagnosis of impacts of climate change in Morocco

Several fields related directly or indirectly to f 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:

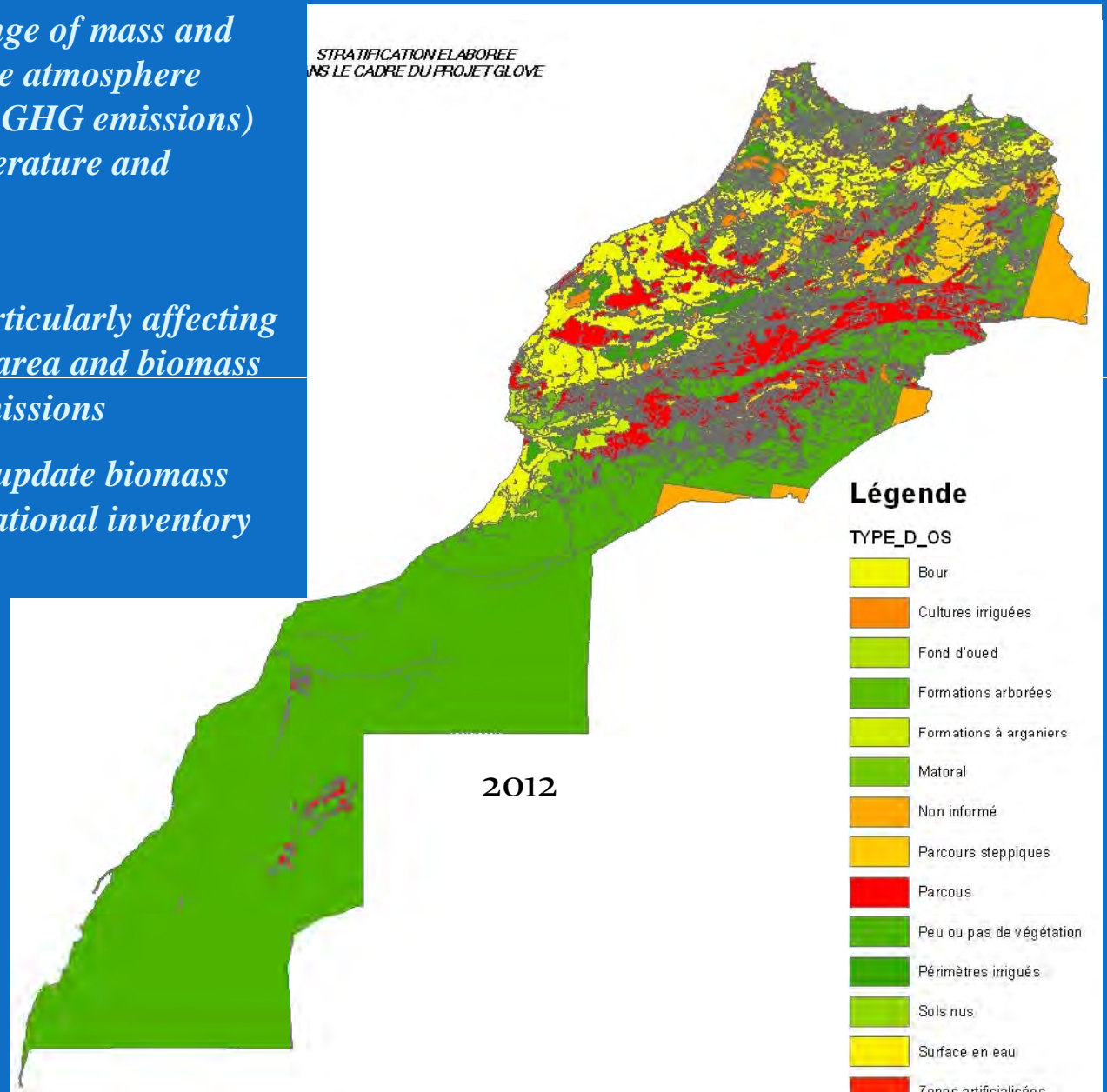
- Contribution to the national inventory of the GHG emissions*
- Characterization and Evaluation of the vulnerability of sectors impacted by CC*
- Assessment of the climate Change impacts*

Mapping land cover and monitoring land use changes at various space and time scales

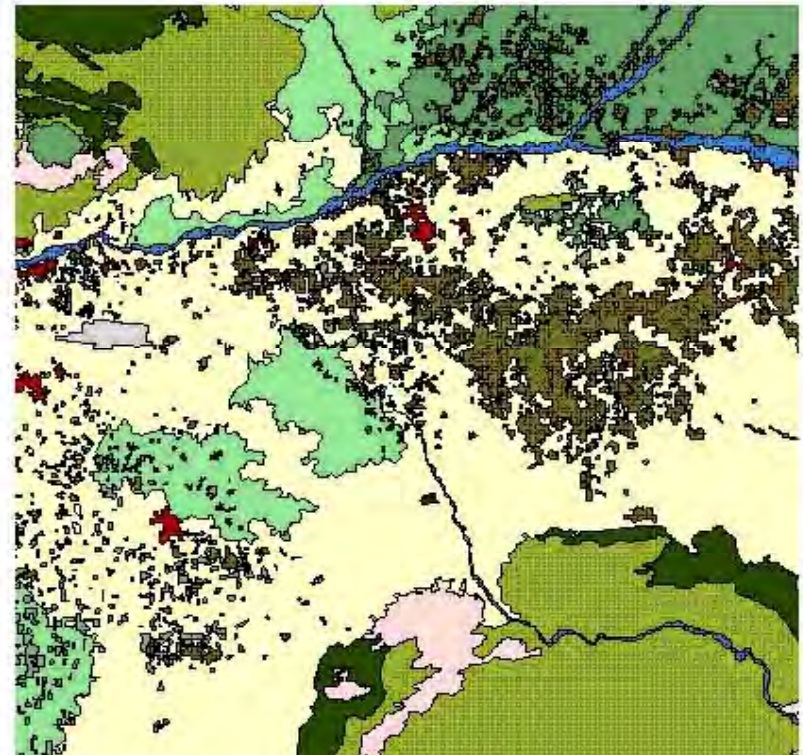
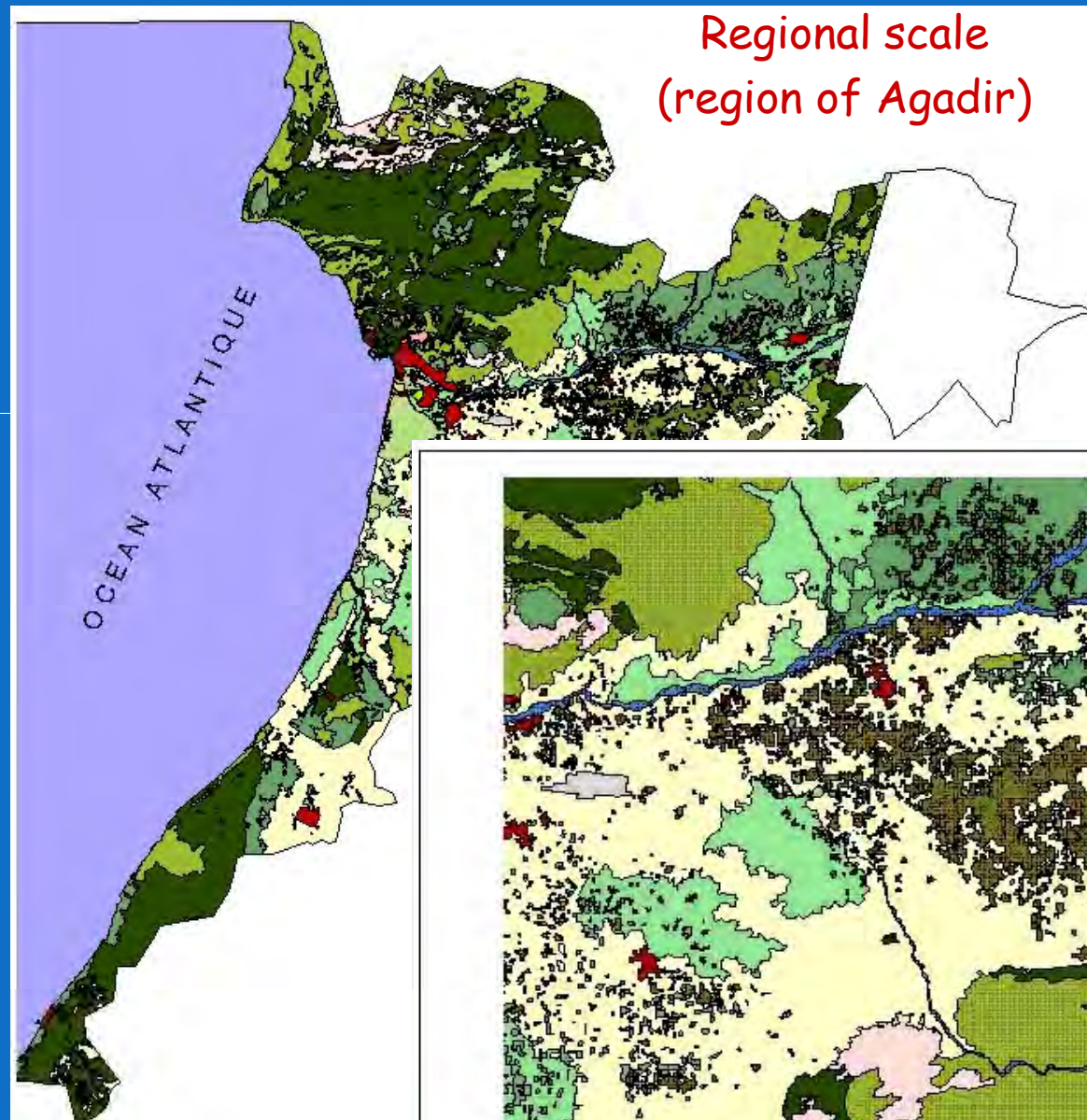
-Land cover influences the exchange of mass and energy between the surface and the atmosphere (energy, carbon dioxide and other GHG emissions) and therefore influences the temperature and climate

- 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 of the updating of national inventory of GHG



Mapping land cover and monitoring land use changes at various space and time scales



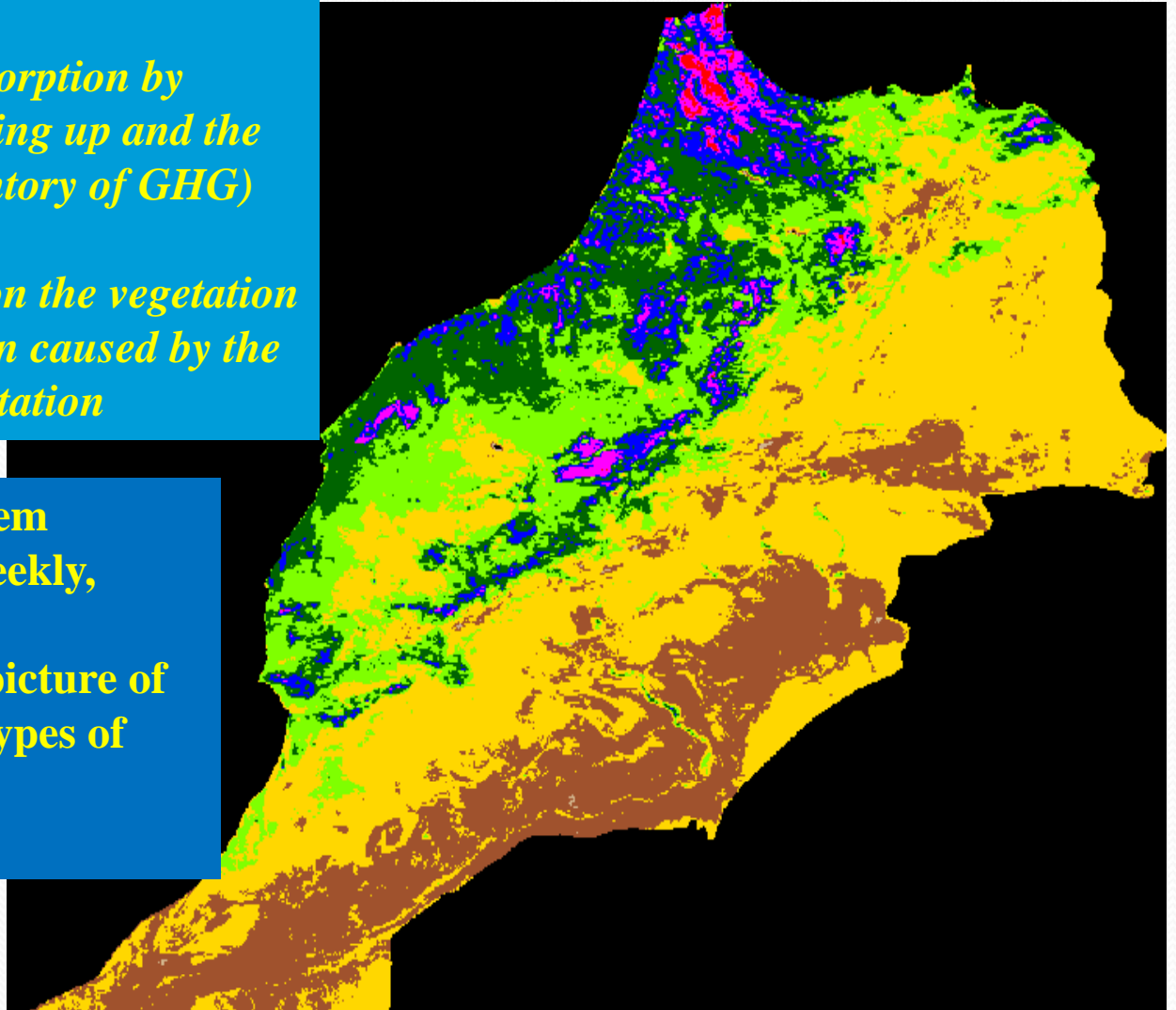
Monitoring of global vegetation conditions and changes

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*

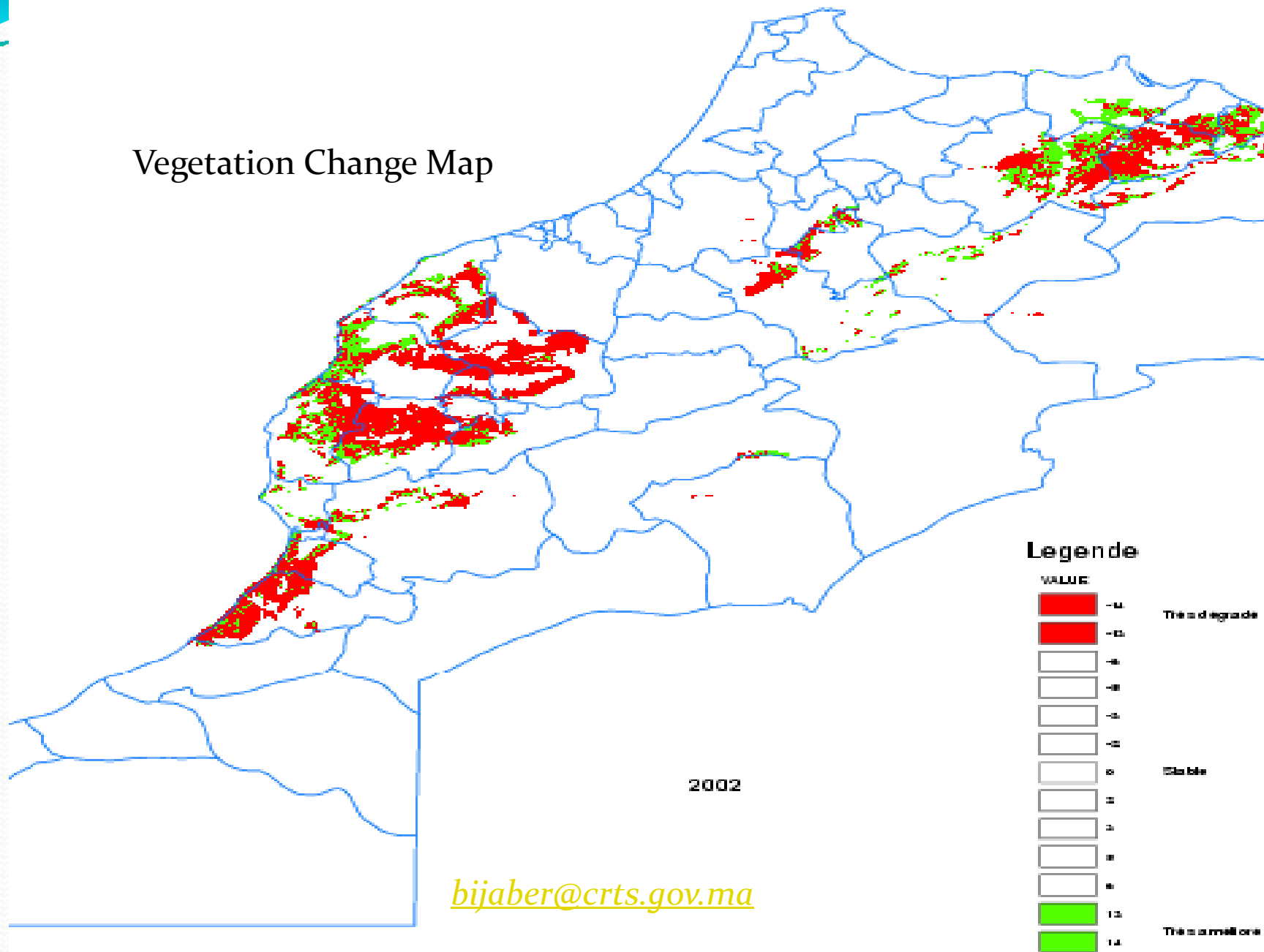
- Operational monitoring system producing maps describing weekly, monthly and seasonal changes
- Providing a comprehensive picture of the development of different types of vegetation



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



Implementation of a Drought Early Warning System

Justification:

1. Importance of agriculture in the Moroccan economy
2. High inter annual 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)

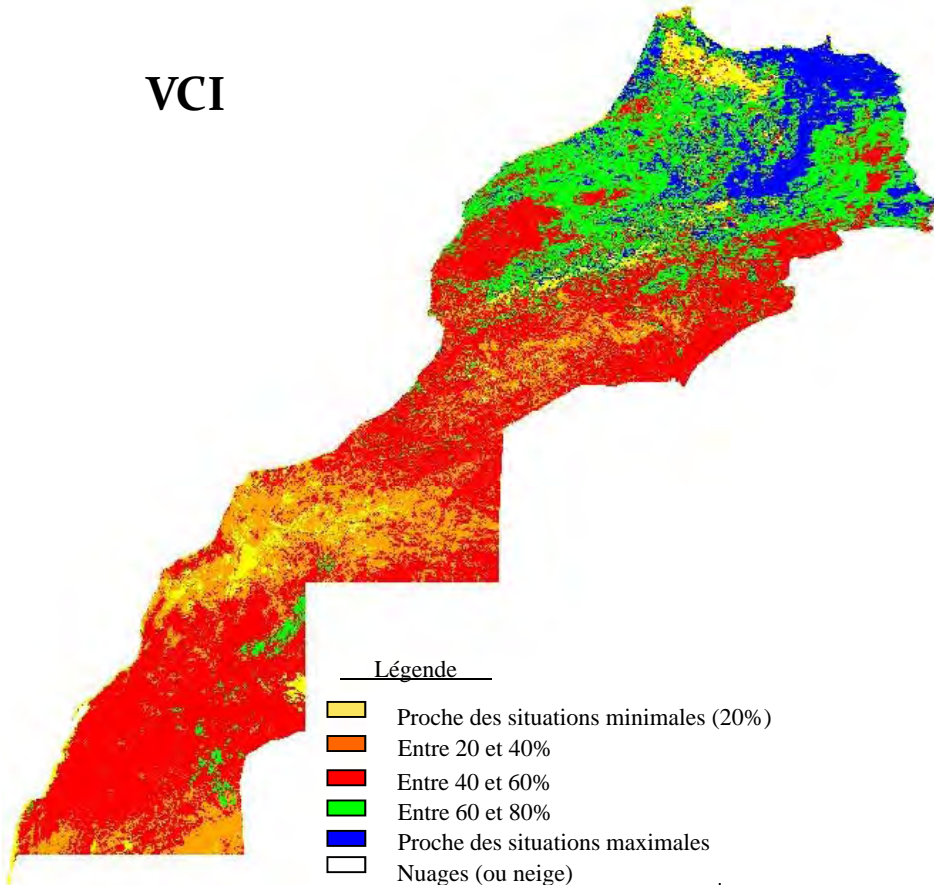
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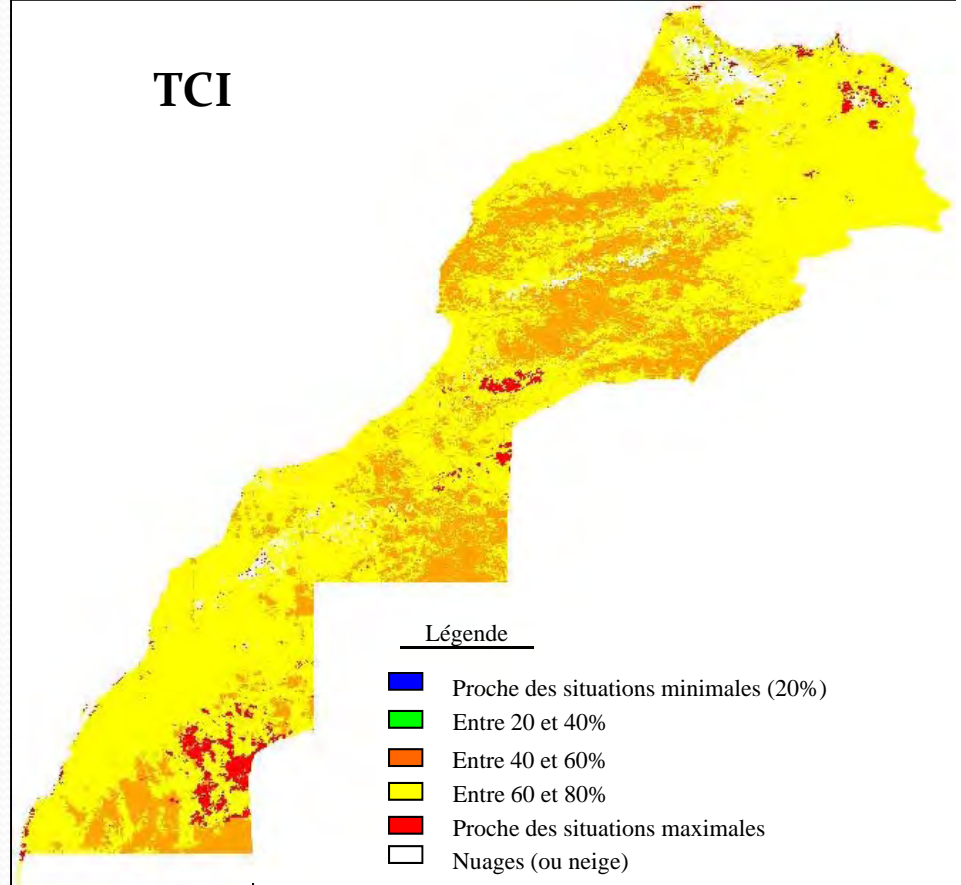
Implementation of a Drought Early Warning System

Indicators

VCI



TCI



$$VH = 0,5 VCI + 0,5 TCI$$

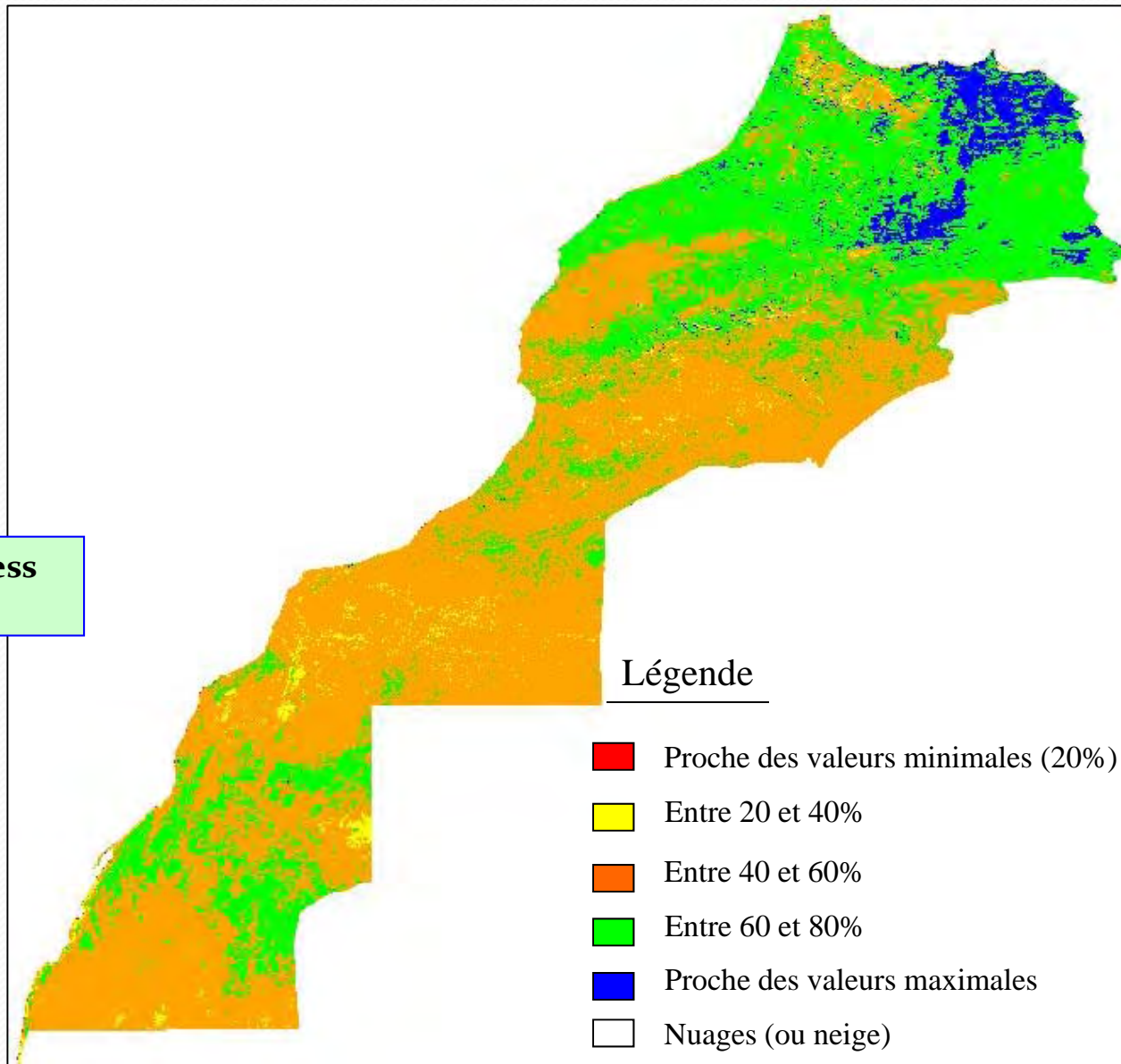
Décade 3, Mars 2012

Implementation of a Drought Early Warning System

Indicators

VH
Mars 2012
Decade₃

$VT < 40\% \rightarrow$ stress
(Kogan)



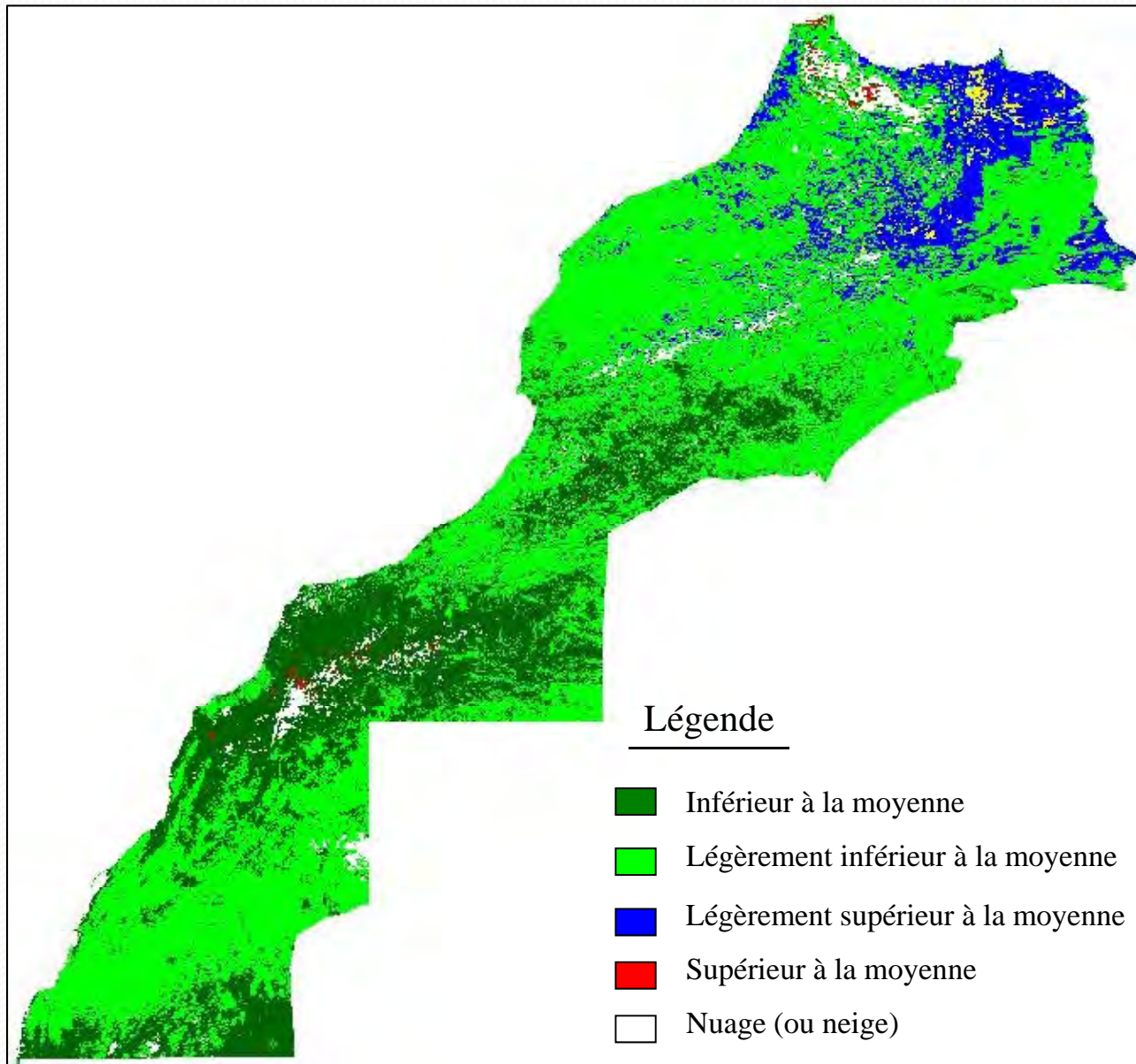
Implementation of a Drought Early Warning System

Indicators

SVI

Mars 2012

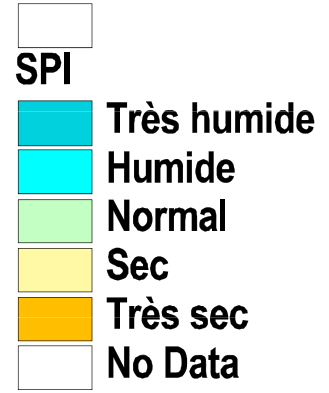
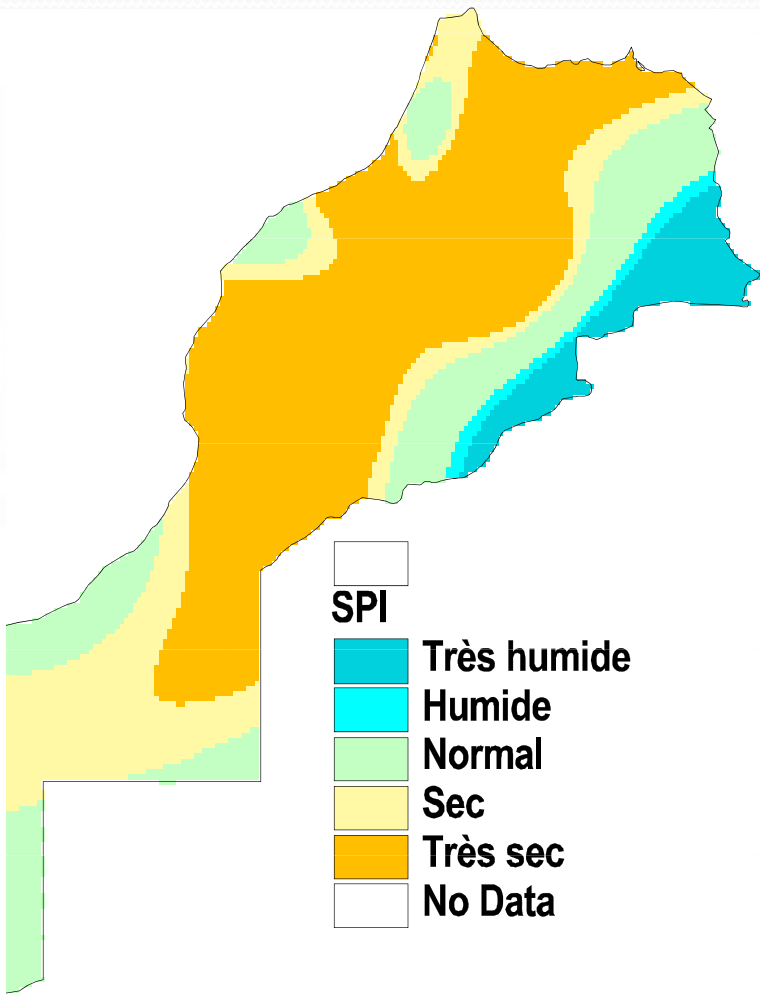
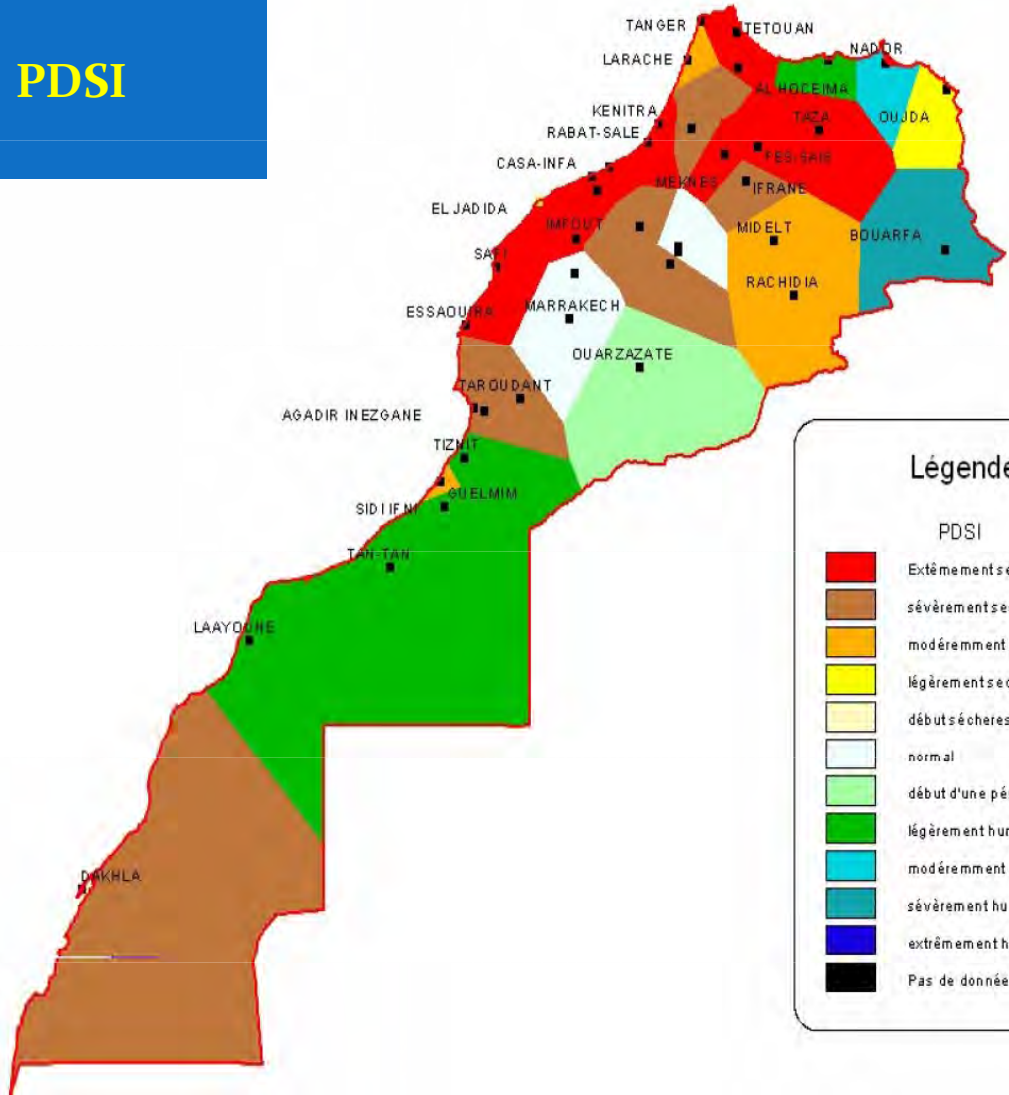
Décade 3



Implementation of a Drought Early Warning System

Indicators

PDSI



Desertification monitoring and assessment of degraded lands

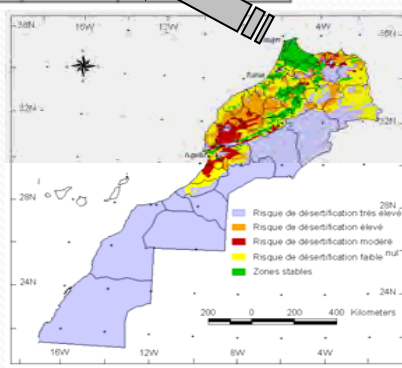
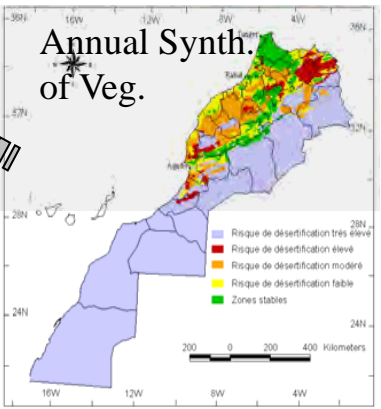
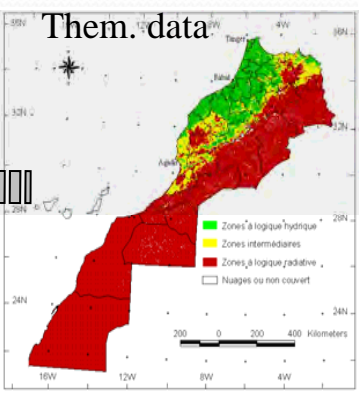
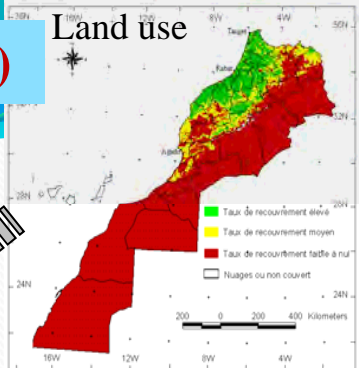
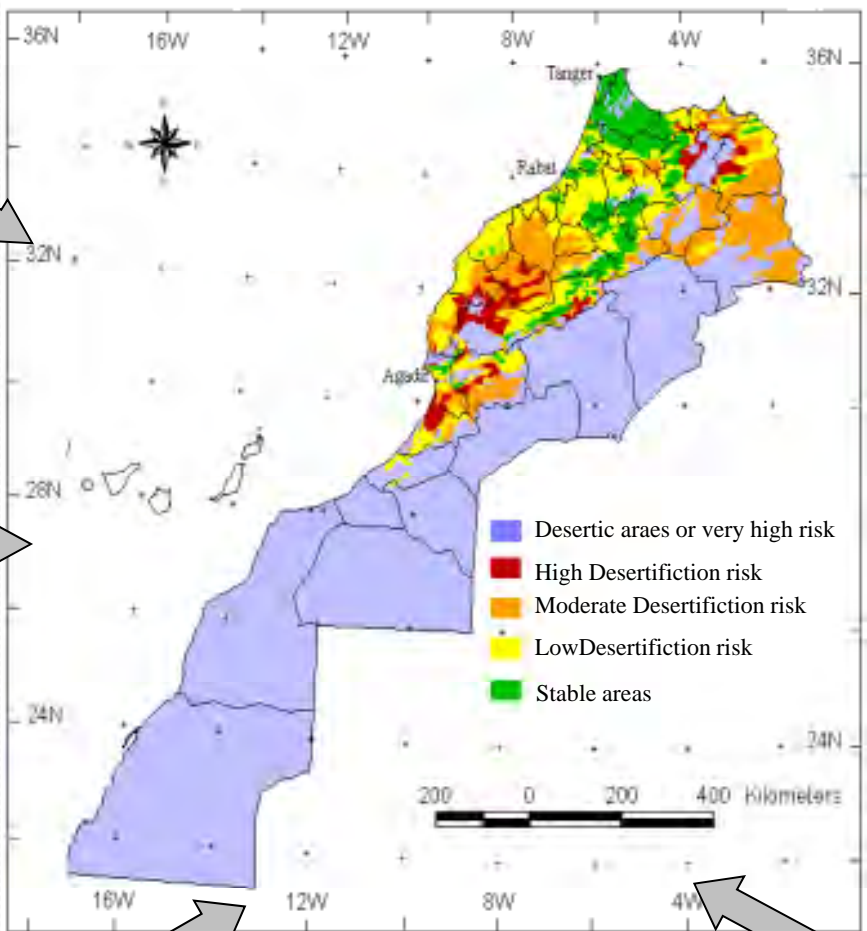
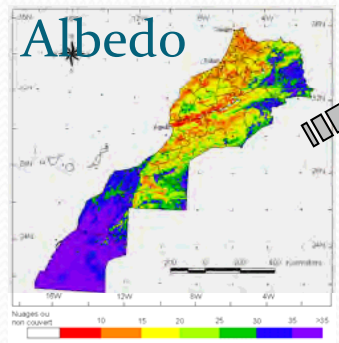
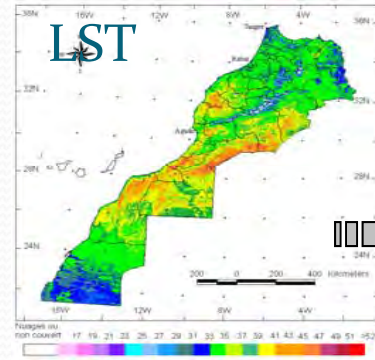
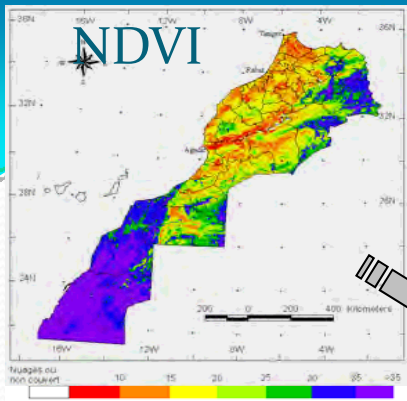
- Deforestation : 33.000 ha/year
- Degradation of rangelands : 8,3 M ha
- Over Pasturage: more than 23% of the capacity rangelands
- Hydric erosion: Threat 2/3 of cropland
- Stalinization: affects 37.000 hectares of irrigated lands

+ *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)



In situ Data

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bijaber@crts.gov.ma

Annual map of hydric conditions.

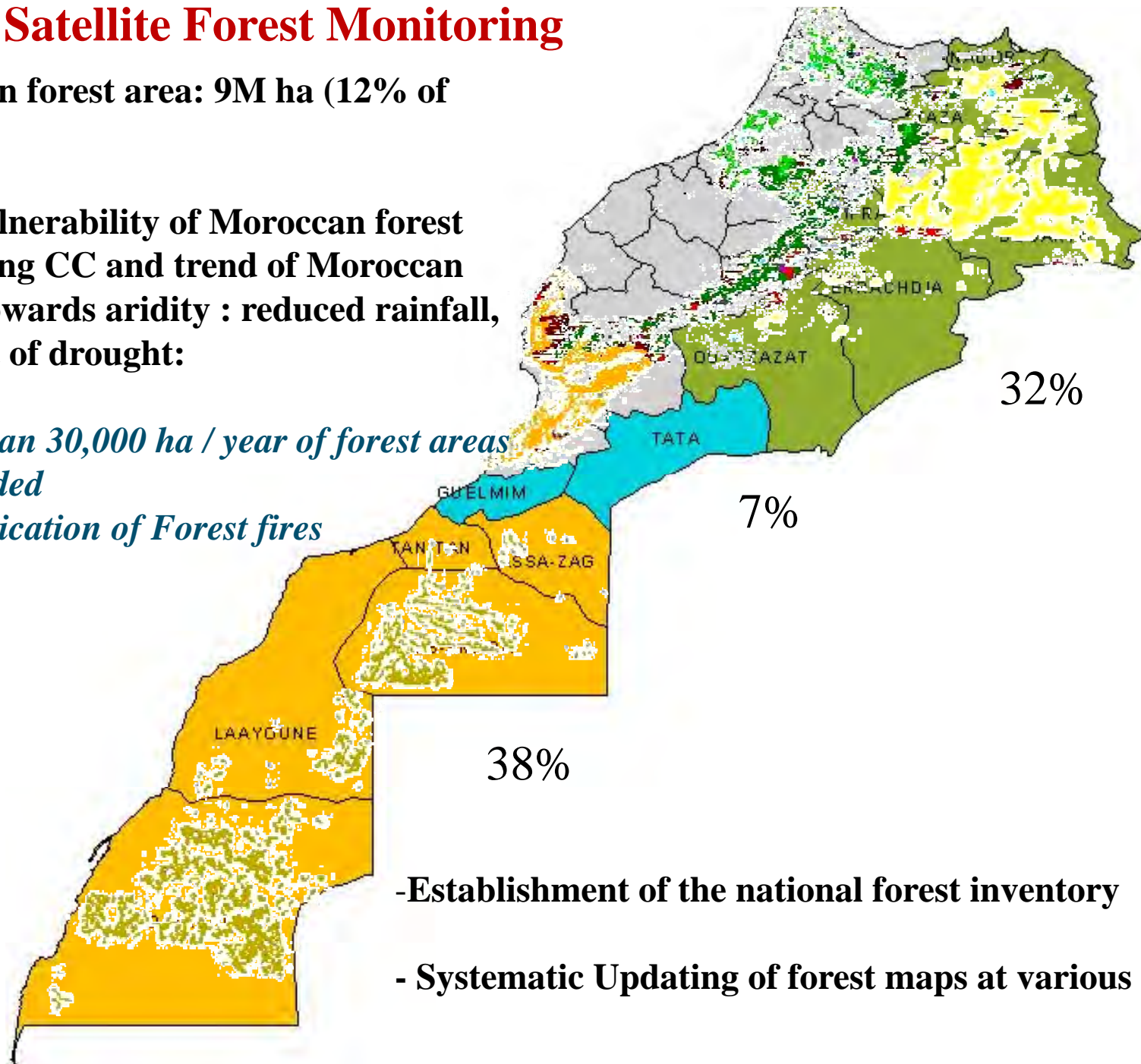
Satellite Forest Monitoring

-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

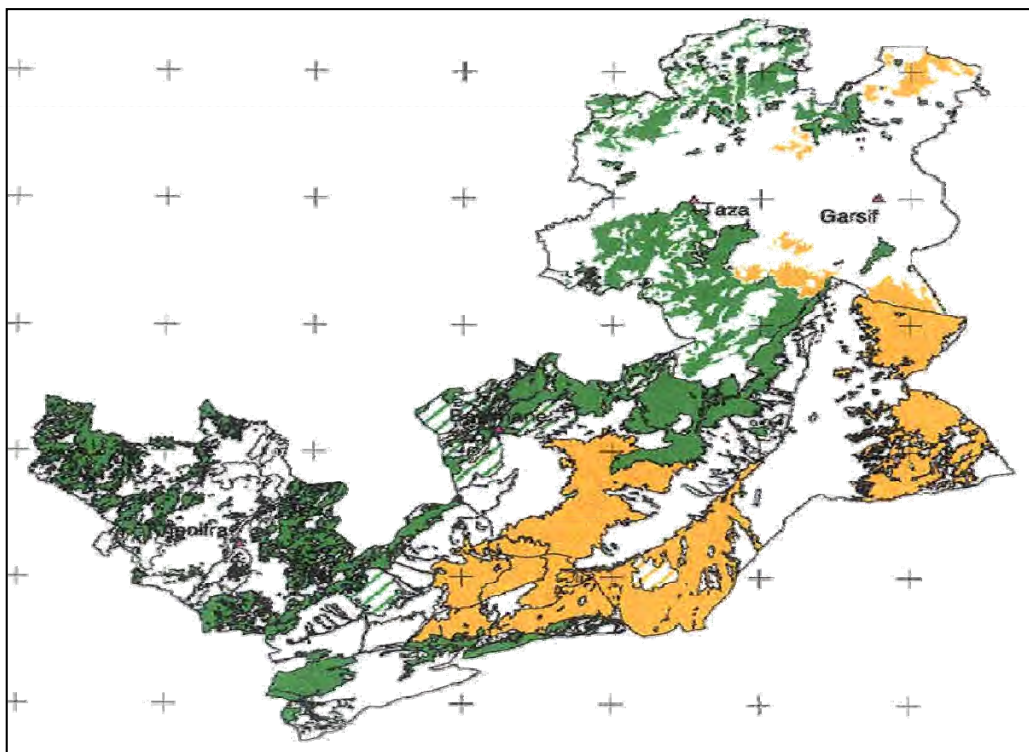


-Establishment of the national forest inventory

- Systematic Updating of forest maps at various scales

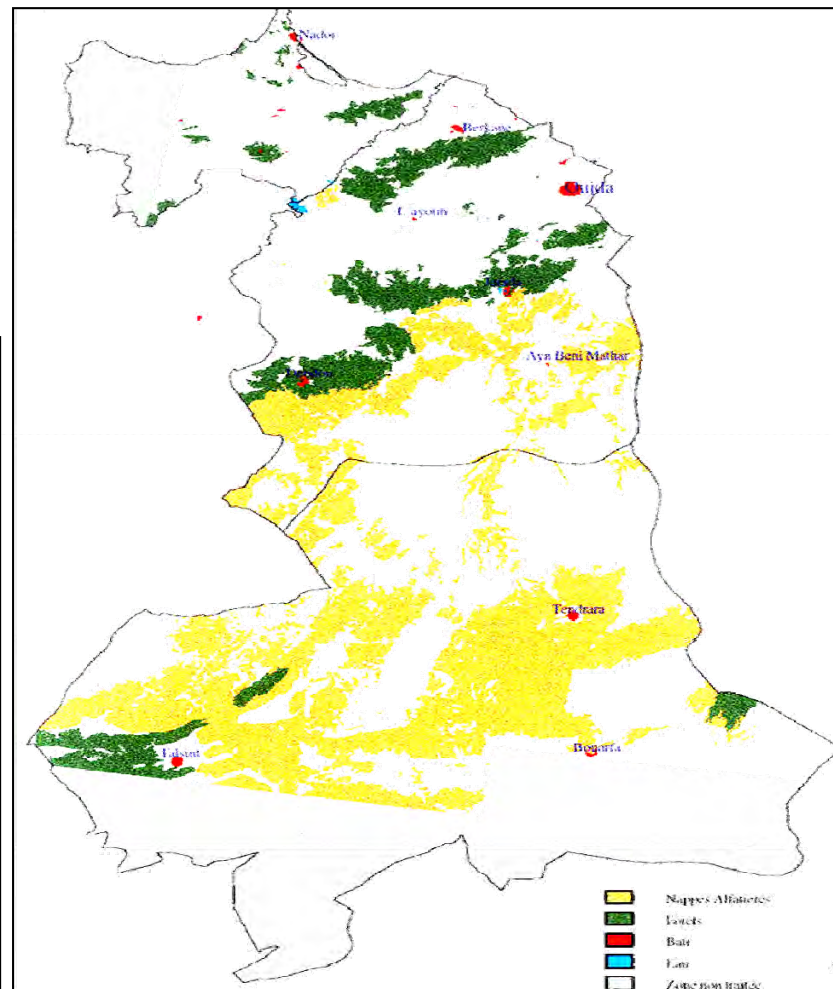
Forest Monitoring

Forest maps



a part of Atlas Mountains

Regional scale

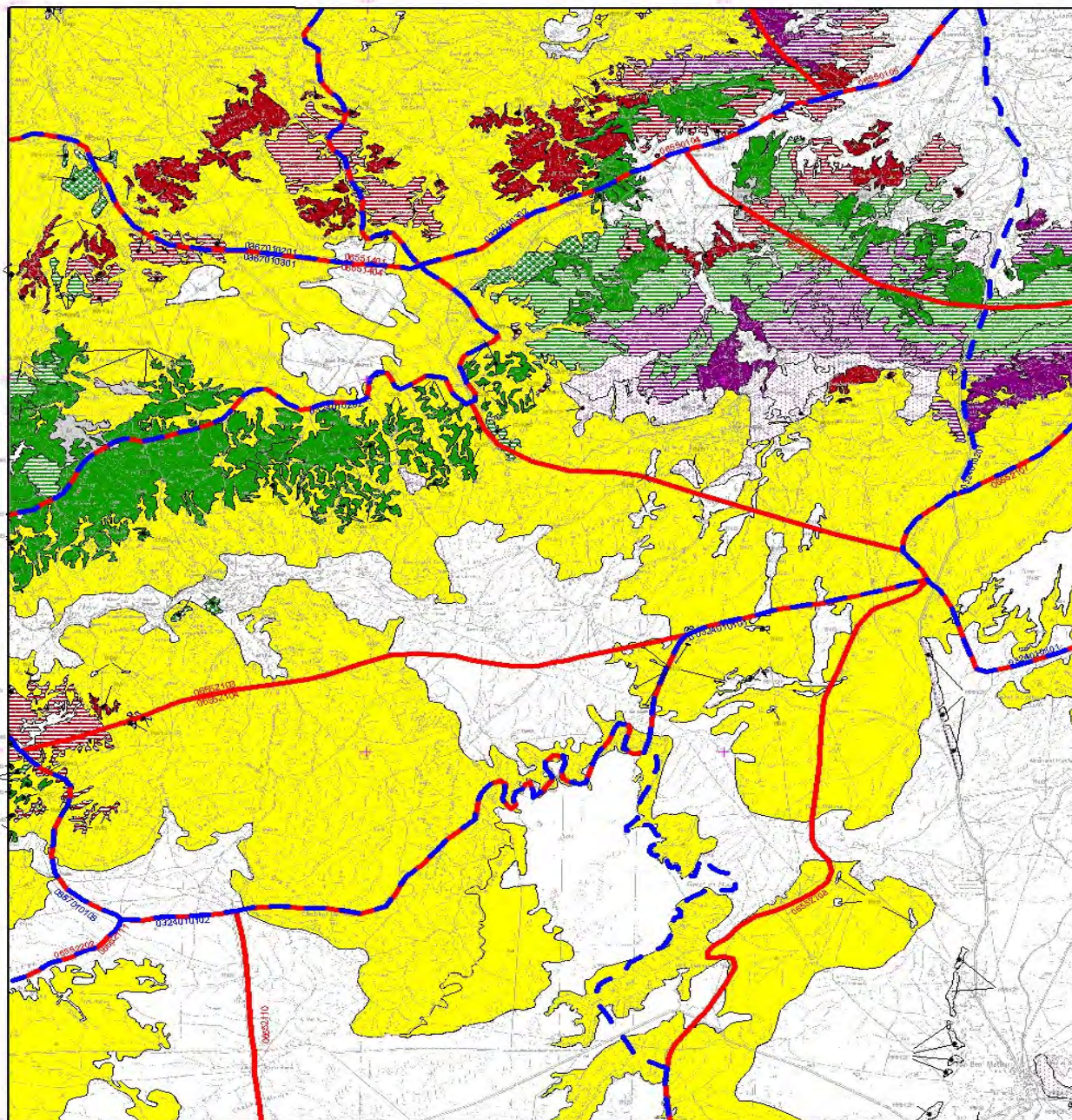


Oriental

Monitoring of Forest areas

1/50000

Ain Beni Mathar









-  Cèdre
-  Pin
-  Genévrier
-  Thuya
-  Sapin
-  Autres résineux

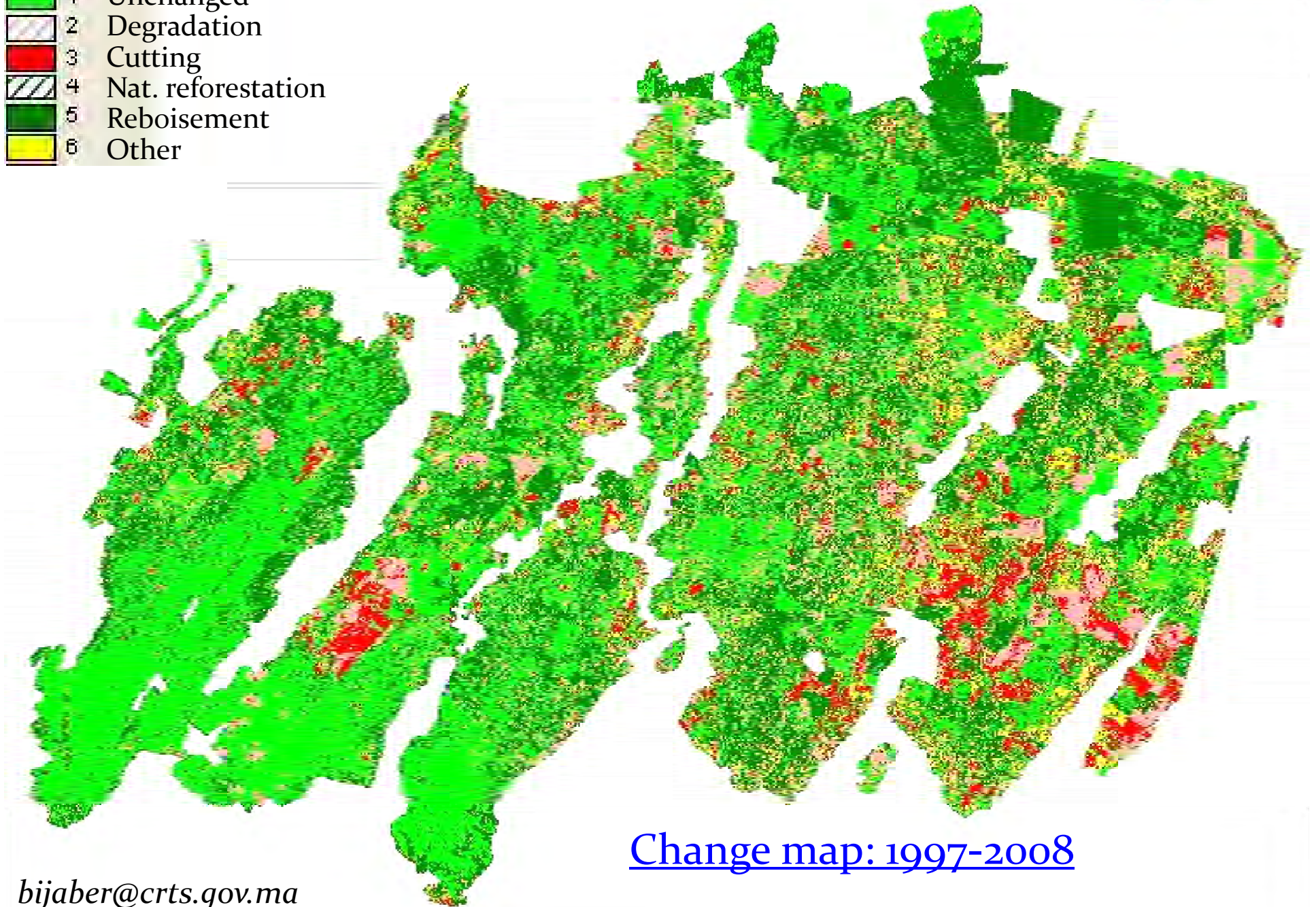
-  Acacia saharien
-  Tamarix
-  Chêne liège
-  Chêne vert
-  Chêne zeen
-  Arganier
-  Autres feuillus

-  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

	1	Unchanged
	2	Degradation
	3	Cutting
	4	Nat. reforestation
	5	Reboisement
	6	Other



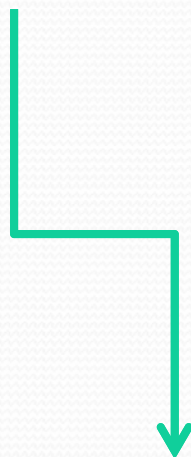
[Change map: 1997-2008](#)

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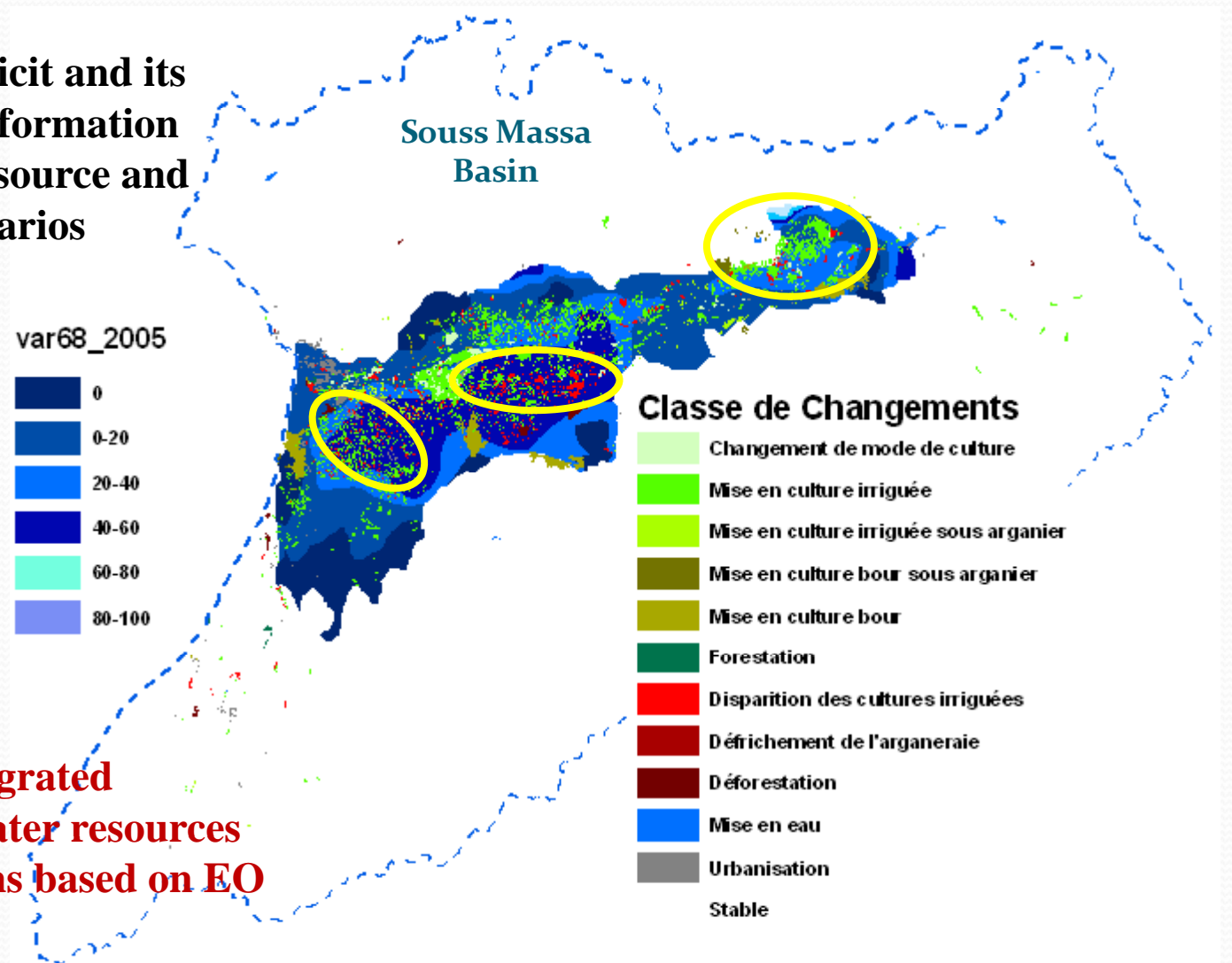
Managing water resources

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



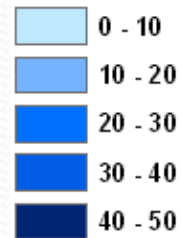
Development of an integrated approach to manage water resources in some hydraulic basins based on EO and In situ data



Managing water resources

Forecasting changes in the depth of the water layer in 2020

Variation 2005-2020



Classe de Changements



er-raji@crts.gov.ma

New Project : LDAS (Land Data Assimilation System)

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

Objectif :

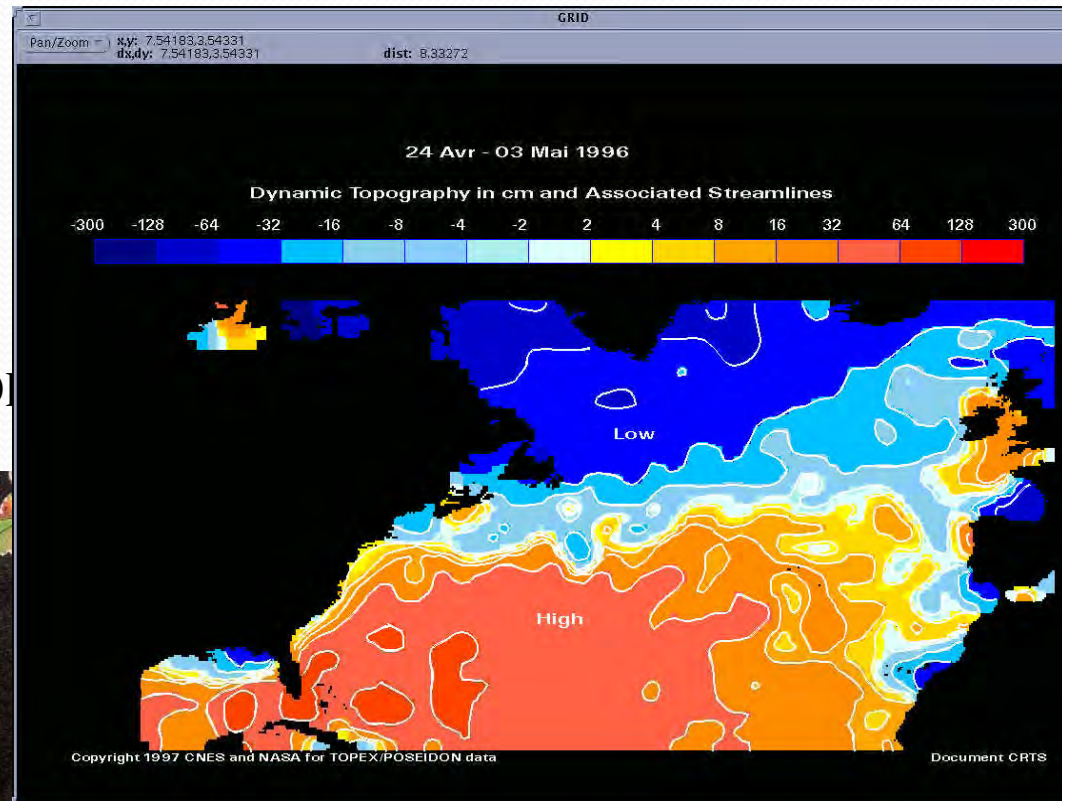
Strengthen national capacities to assess climate change impacts on water conditions :

- 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**

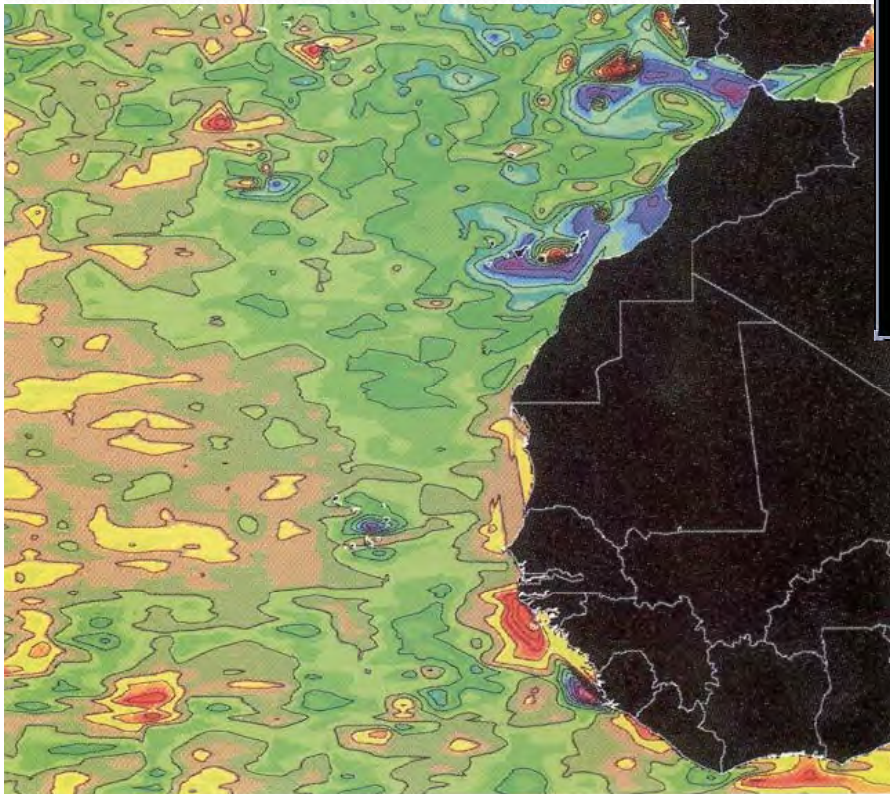
Monitoring and analysis CC impacts of CC in marine and coastal areas

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

Altimetry data : TOPEX and POSEİDON

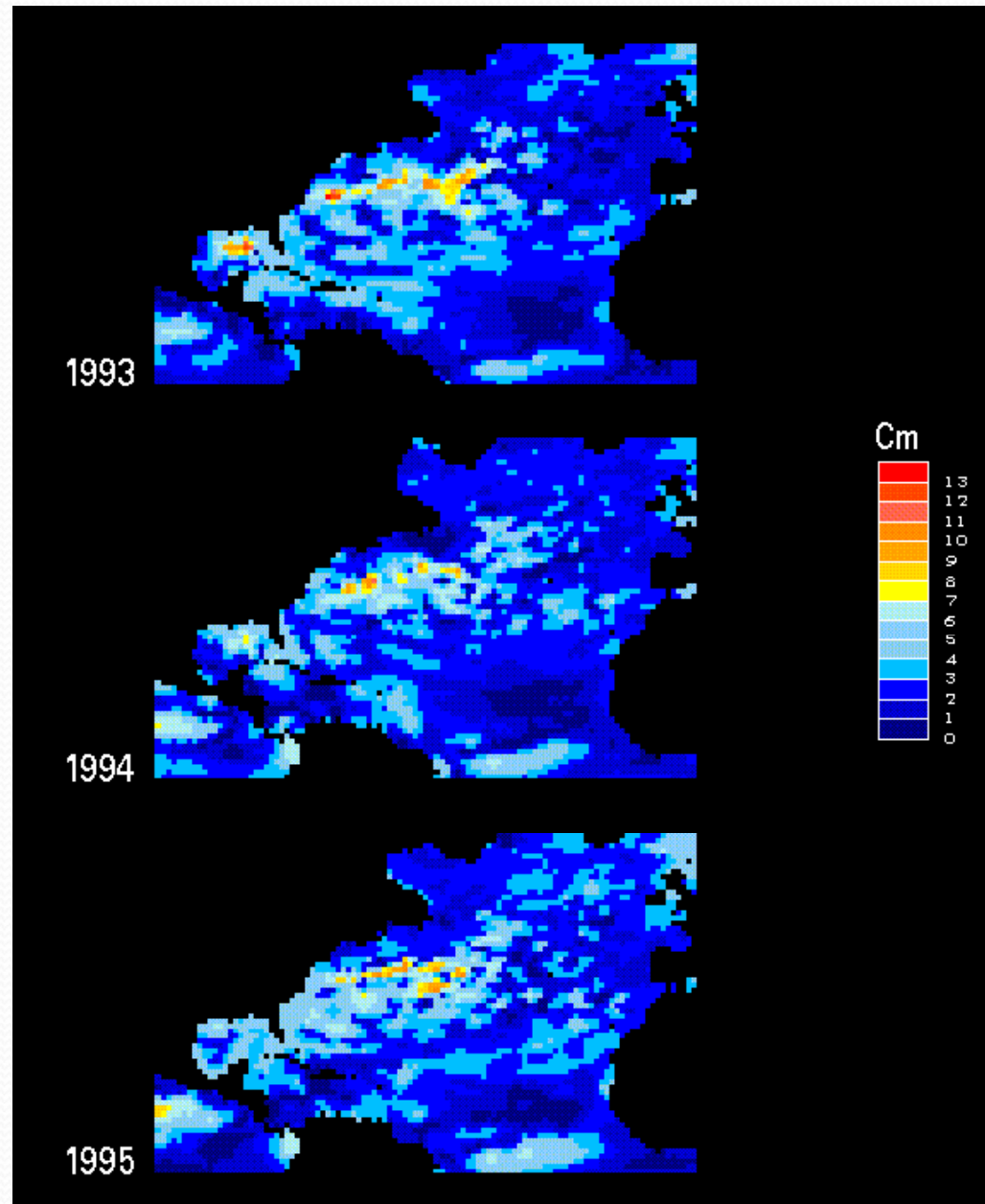


Sea level rise



Monitoring and analysis CC impacts of CC in marine and coastal areas

Anomalies Maps of Surface of Sea Level (SLA)

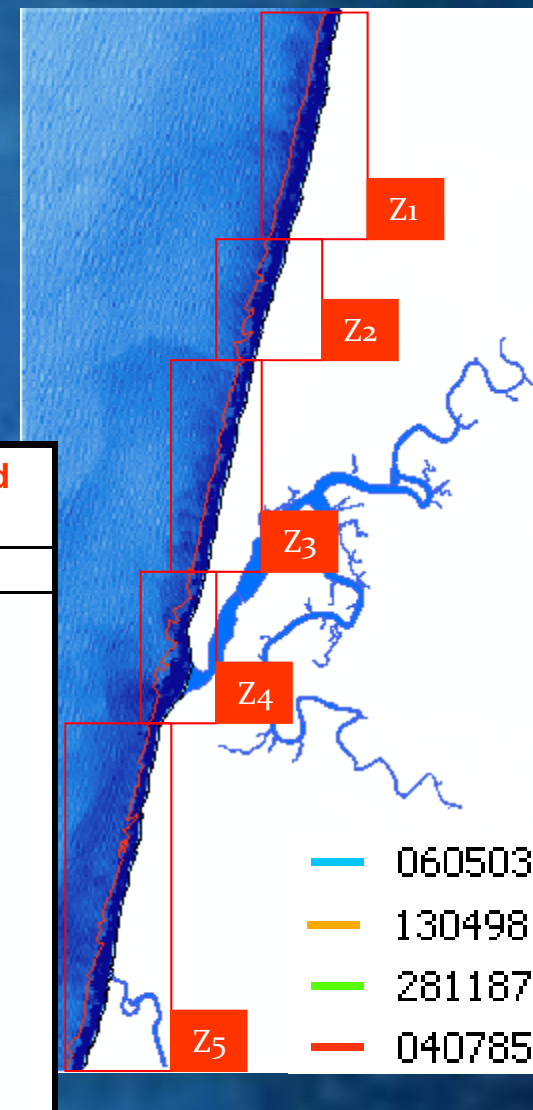
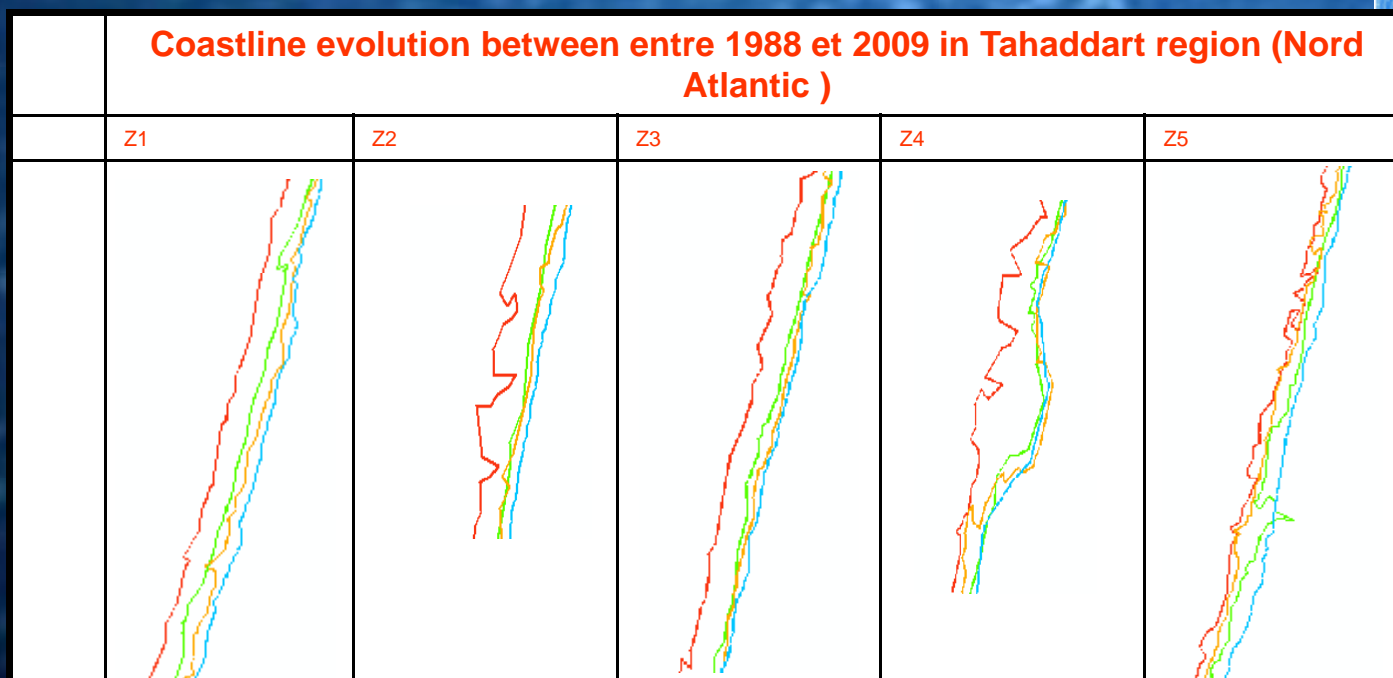


Monitoring of coastal dynamics and evaluation of coastline erosion

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

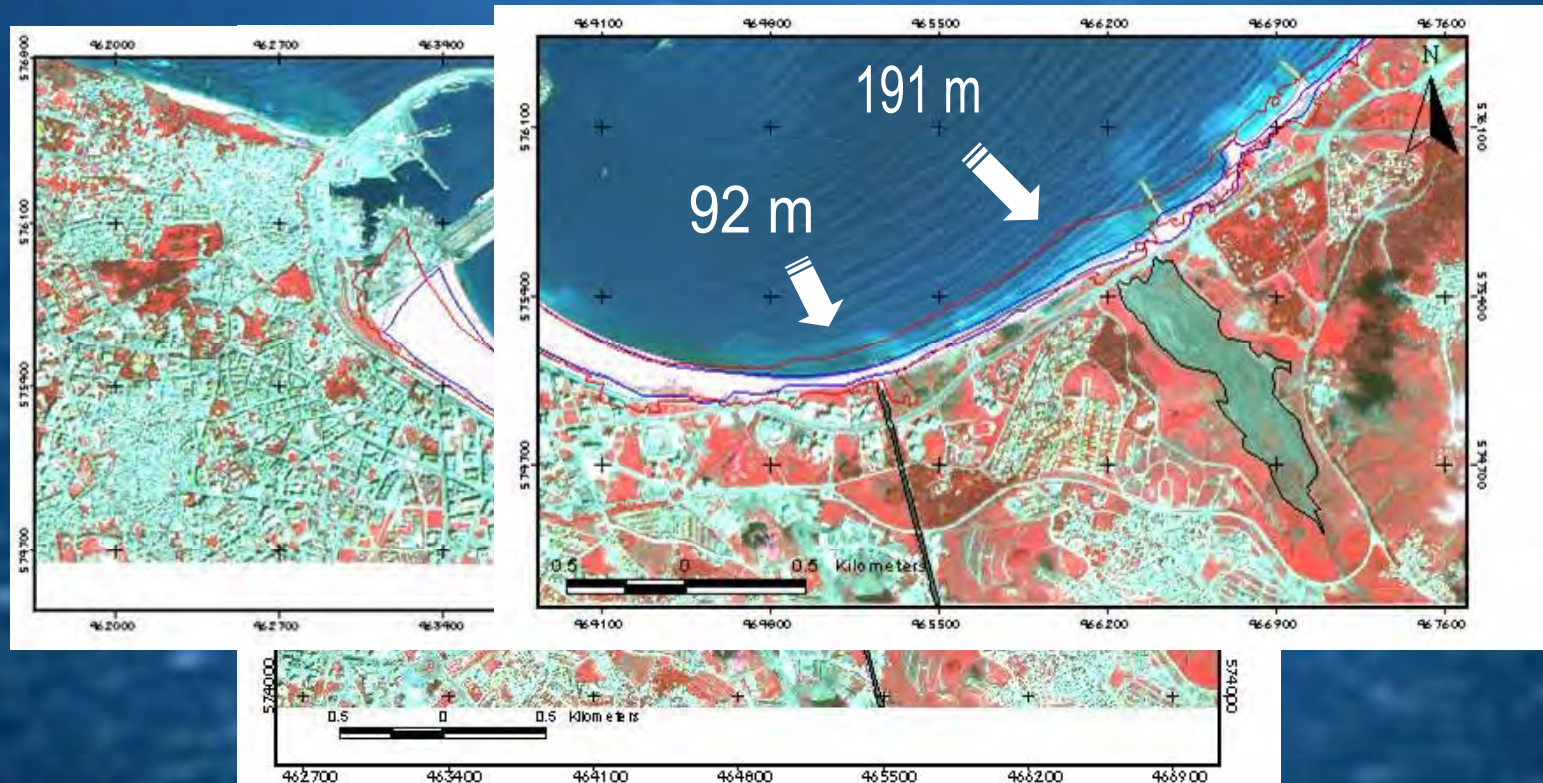
- Quantification of the coastline dynamic intensity and delimitation coastal zones suffering degradation: fast erosion sectors, thrust sectors...



Monitoring of coastal dynamics and evaluation of coastline coast line decline

Examples on Mediterranean Sea

Tanger



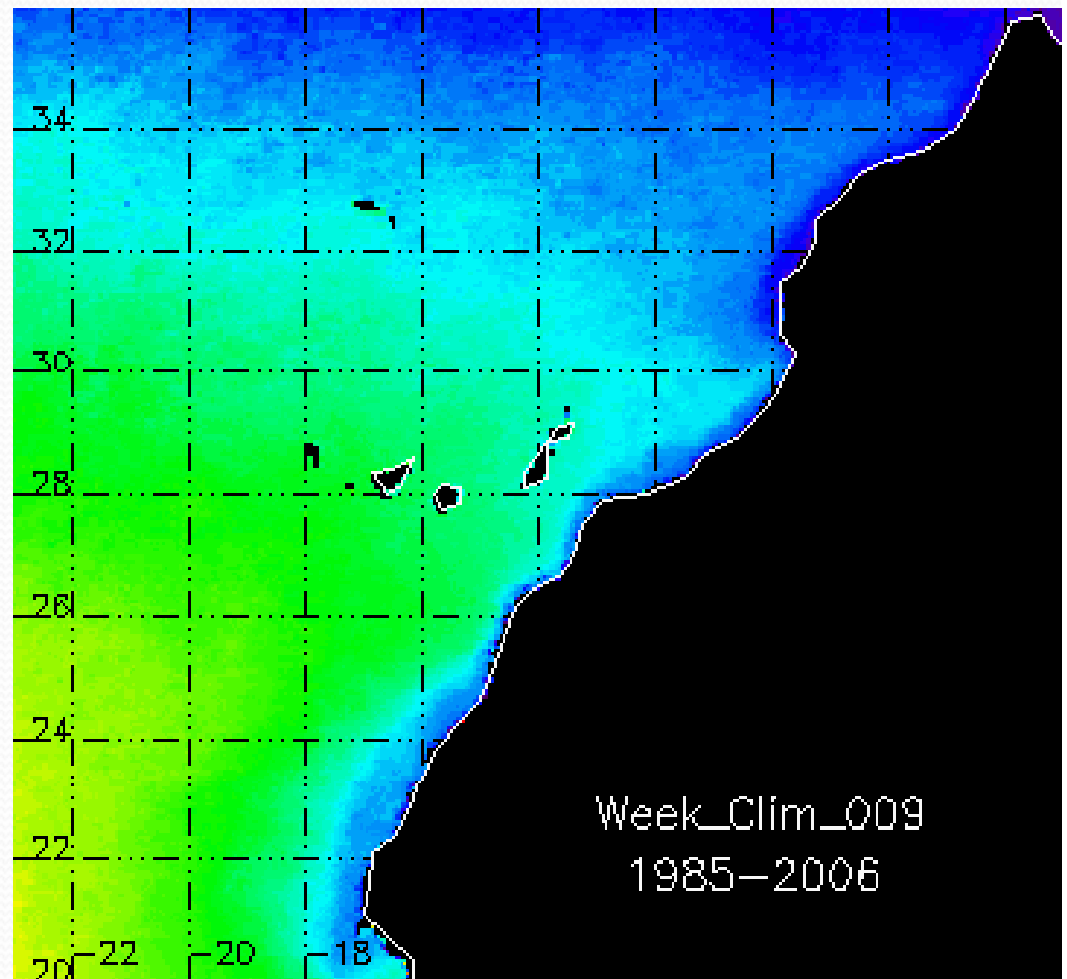
Plage 54 Plage 87 Plage 03 Engraissement Erosion

Detection and monitoring of upwelling

- Important phenomenon for the Moroccan fisheries

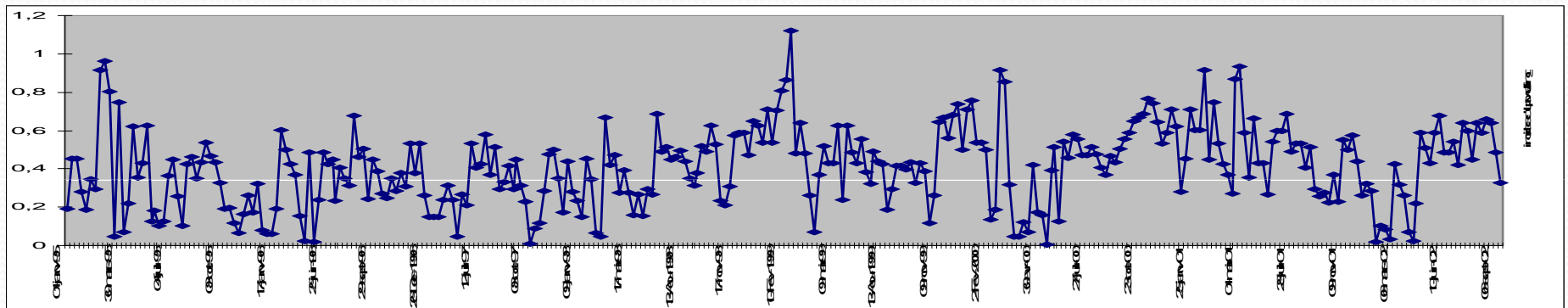
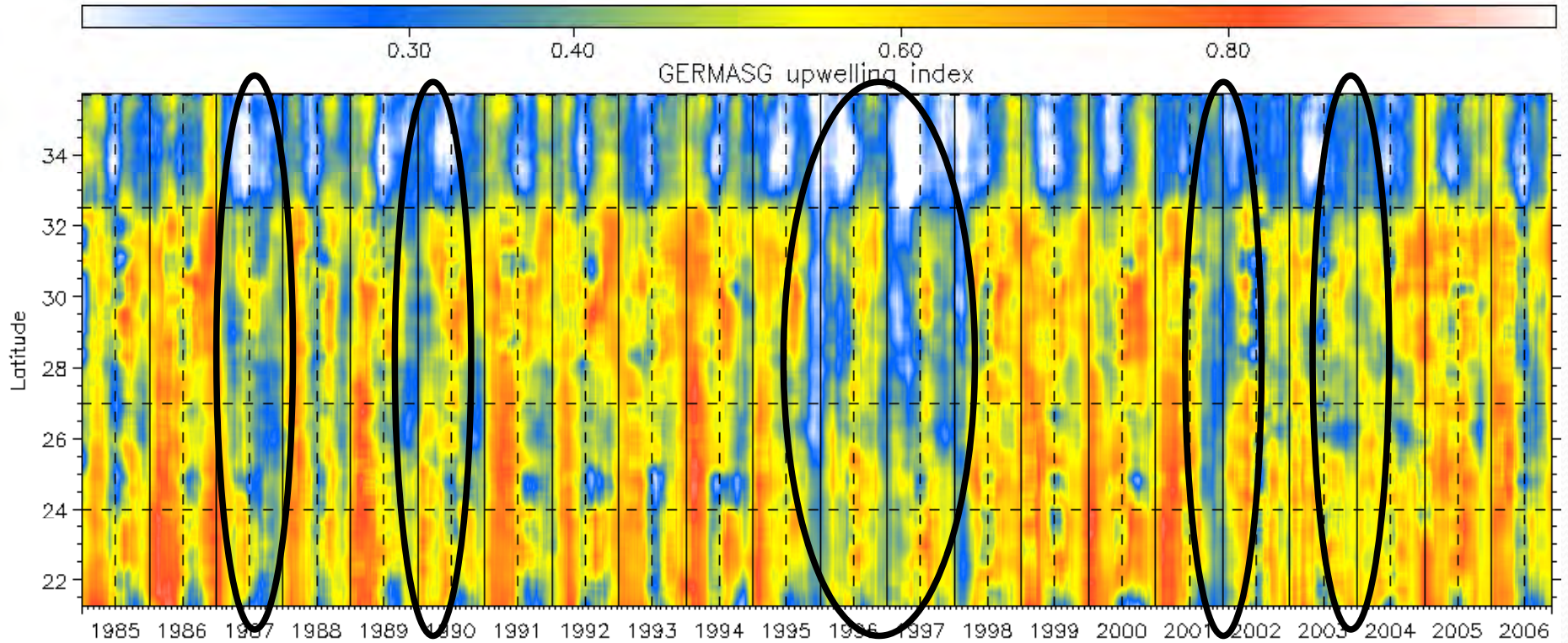
- Phenomenon hydro climatic largely influenced by changes in climatic conditions (winds fluctuations)

- Development of operational monitoring products of upwelling (SST, Chlorophyll a, upwelling index) to Support management of fisheries and stock forecasting



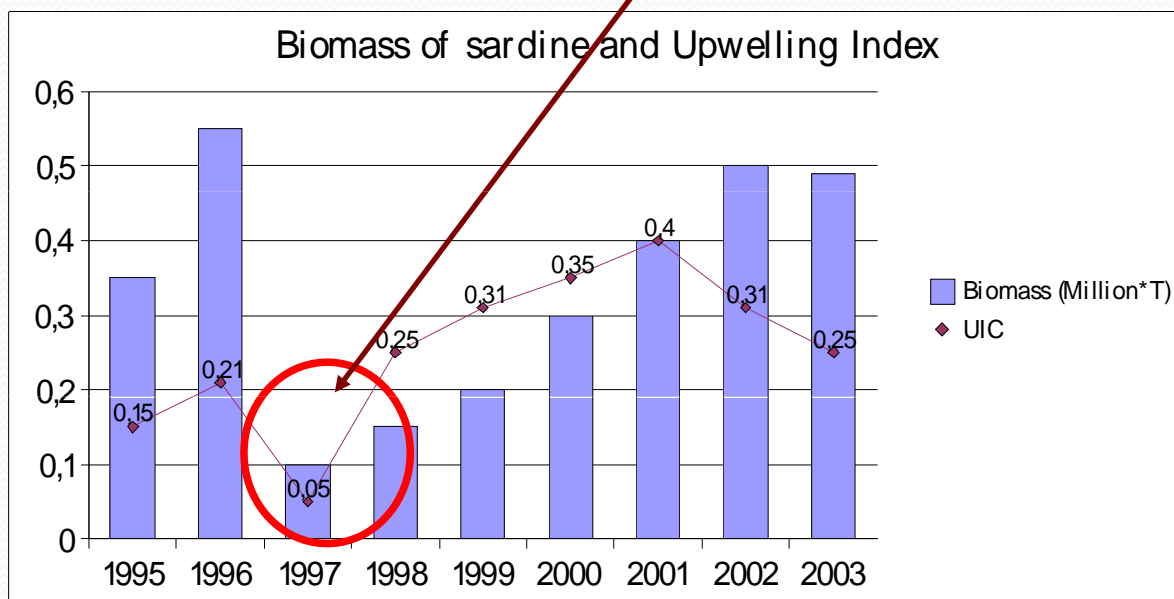
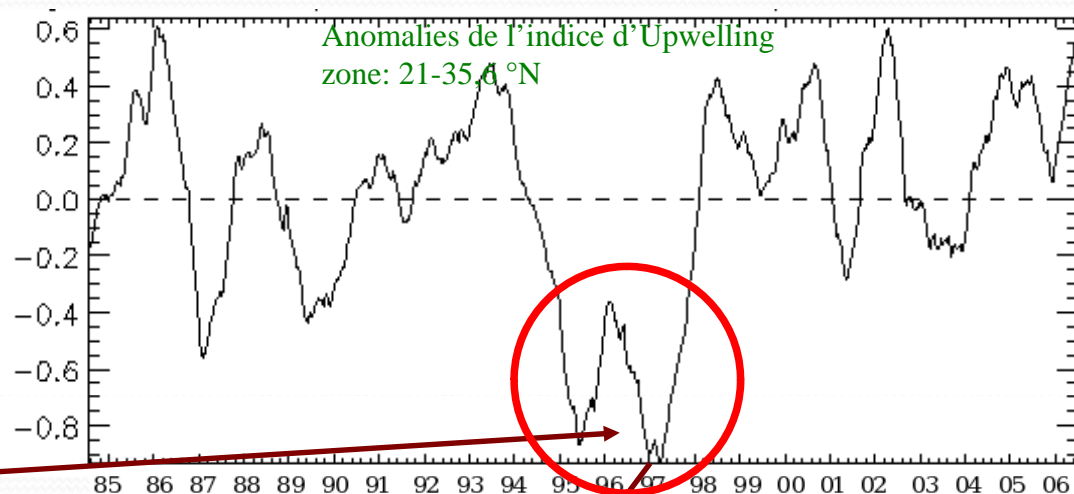
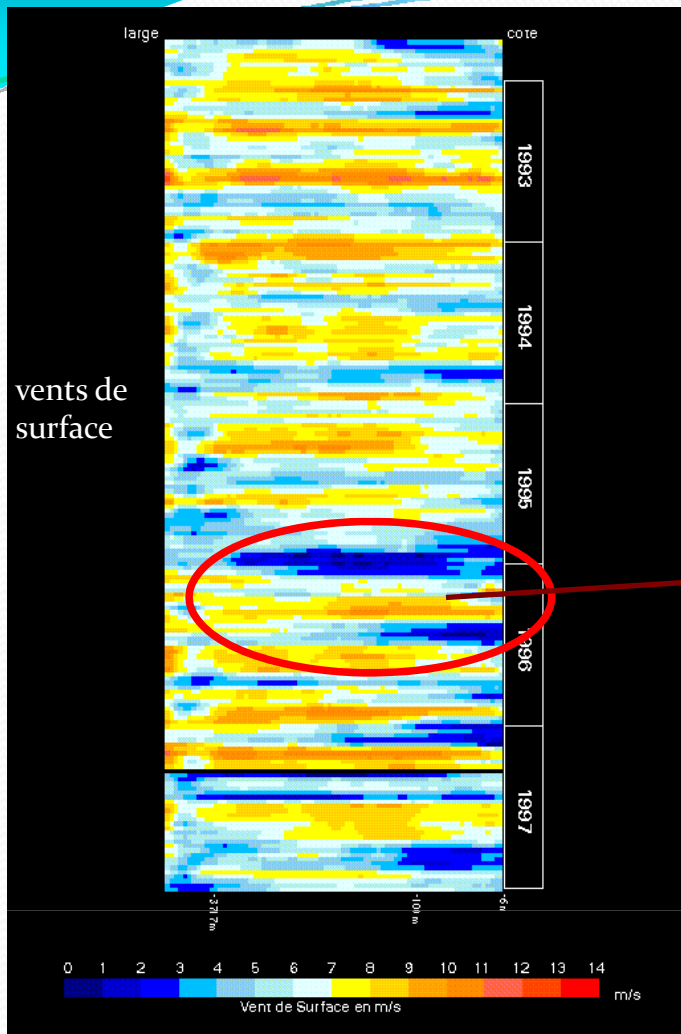
Detection and monitoring of upwelling

Interannual evolution Upwelling index along Moroccan coasts



Detection and monitoring of upwelling

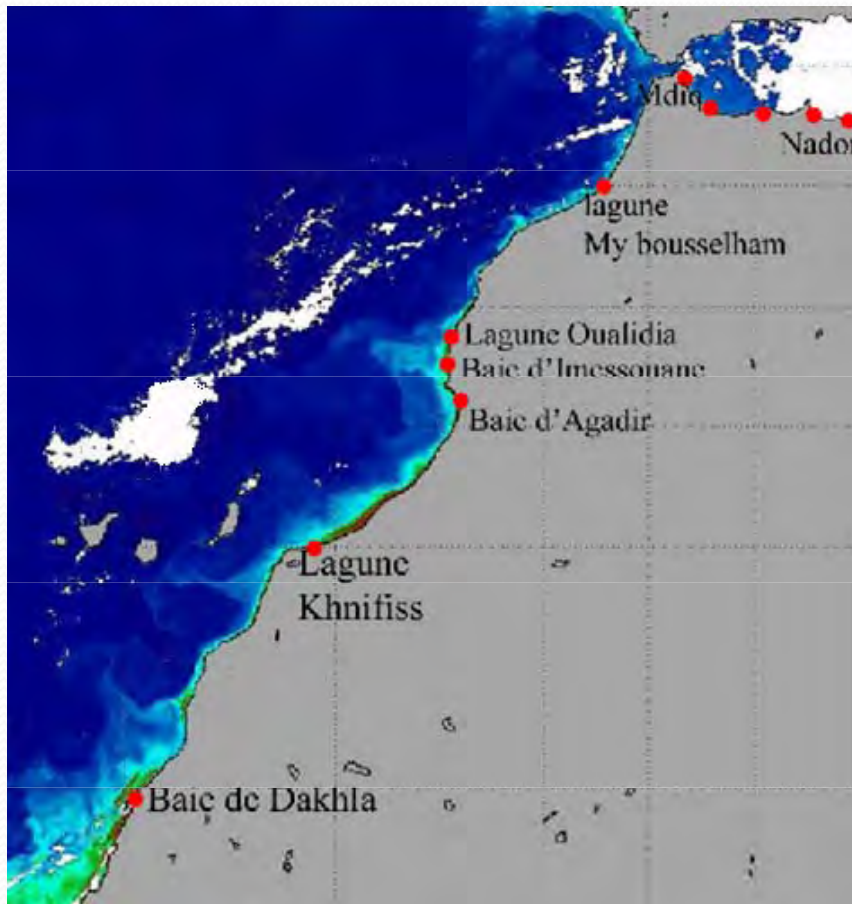
Example of Relationship between Climate (Wind), upwelling and fisheries (1996 - 1997)



Annual evolution of sardine biomass estimated by acoustic (1995-2003)
(source: Fridjof Nansen cruises)

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



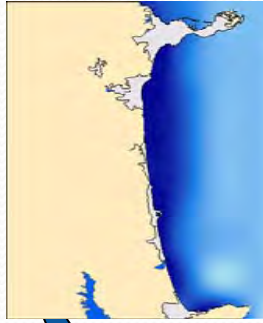
Open Bay

Development of Geographic Database

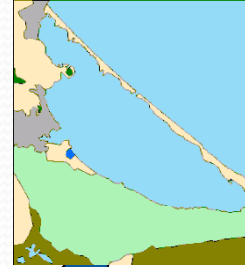
-In situ measures - Climate data

DATE	HEURE	PROF_M	LONG_e	LAT_n	TS_e
15.4	36.4	8	0.93333	13.84928	3.88889
15.3	36.4	7.3	1.4	25.9913	9.33333
15.2	36.4	8.1	0.46667	22.57681	10
15.1	36.4	8.2	0.93333	15.15362	1.55556
15.3	36.4	8.2	2.8	34	8.5
15.2	36.5	8	2.33333	32.44928	17.11111
15.2	36.4	8.2	2	30.4	1.55556
15.1	36.4	8.4	1.63333	29.23623	20.22222
15.4	36.2	8.2	1.4	37.73043	10.11111
15.4	36.5	8.2	1.86667	13.78551	10.88889
15.6	36.5	8.4	1.86667	17.26377	7
15.5	36.5	8.3	0.93333	10.37101	7
15.4	36.5	8.2	0.4	10	3.88889
15.4	36.6	8	0.46667	18.6	4.66667

hydrodynamic model results



Vector Data



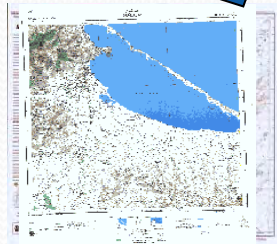
Socio-economic data

I- Les effectifs et leur répartition

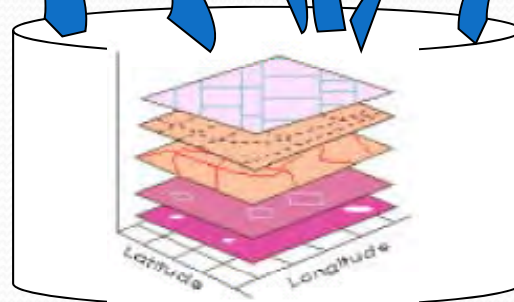
La population de la région d'ouest d'Algerie s'élevait en 1994 à 36.751 habitants, soit 0,1% de la population totale du pays. Elle est caractérisée principalement de rural : 32.000 habitants, soit 87,1% de la population régionale, et 4.751 habitants, soit 12,9% de la population régionale.

La densité moyenne régionale est de 0,3 habitants au km². Cette densité est très faible par rapport à la moyenne nationale qui est de 36,7 habitants au km². Cette moyenne cache cependant une forte disparité au niveau régional puisque les trois quarts de la population régionale sont concentrés à la ville de ALGER et la densité avoisine 500 habitants au km².

La population de la région est essentiellement rurale. En 1994, elle comptait 31.148 habitants, soit 84,7% de total régional. Quant à la population rurale, elle a enregistré une évolution rapide en passant de 3.674 habitants en 1982 à 25.633 habitants en 1994. Certains communes rurales ont vu leur population et affichent des densités relativement élevées comme c'est le cas d'El Djajaj dont la population a progressé de 964 habitants entre 1981 et 1994 en passant de 110 habitants à 1.074 habitants avec un taux d'accroissement de 1025%. Cette tendance s'explique par le phénomène de sédentarisation des nomades qui a



Topographic and marine maps



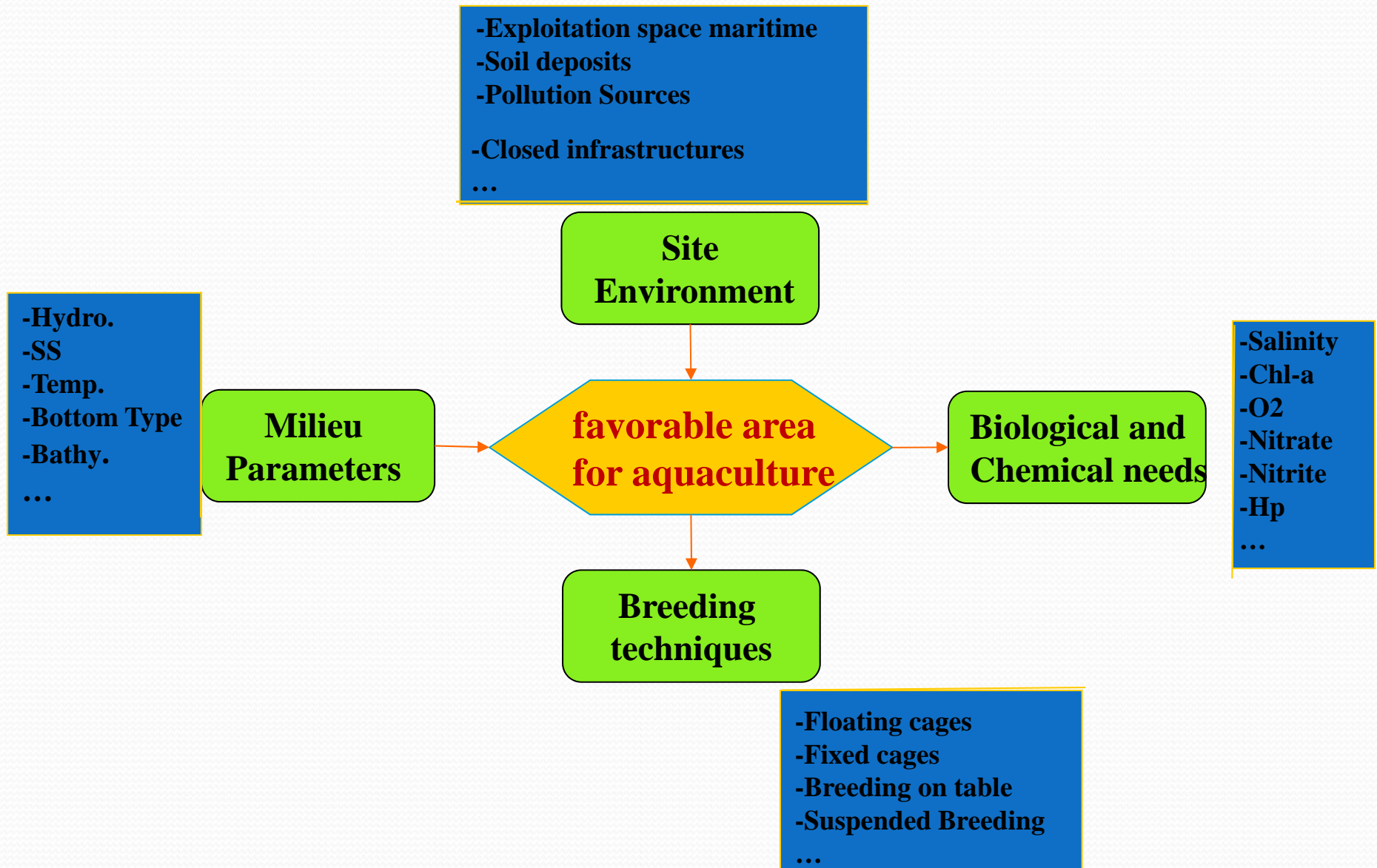
GDB



Satellite Products

Spatial Analysis Model for pre selection of aquaculture areas

Selection criteria species



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