(Ver. Oct.5, 2007)

Remote Sensing Techniques for Evaluating Water Resources




Monitoring LUCC / Environmental Changes
by Satellite Remote Sensing

Recognition of the True Causes of Changes
is the key to Appropriate Water Resources
Evaluation/Management

KONDOH, Akihiko
Center for Environmental Remote Sensing
Chiba University, JAPAN
kondoh@faculty.chiba-u.jp, http://dbx.cr.chiba-u.jp/

How to get the information for Water Resources by Satellite Images

Mode-1 Science(Newton-Descartes type Sciences)

- Extraction of physical parameters
- Combination with the hydrological model
- Computer-based Evaluation / Management

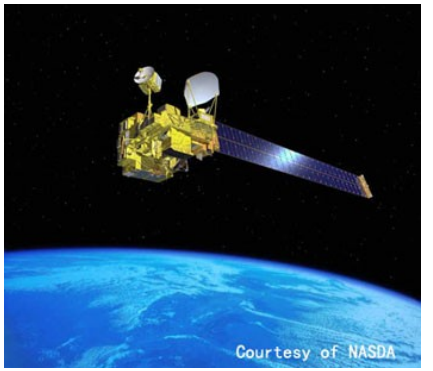
Mode-2 Science(Field Sciences, Environmental Sci.)

- Holistic view to the target region
- Analysis for the relationship among the elements
- Better management based on the true recognition of the actual hydrological, social conditions

Monitoring *Role of Remote Sensing*

What is happen at the site?

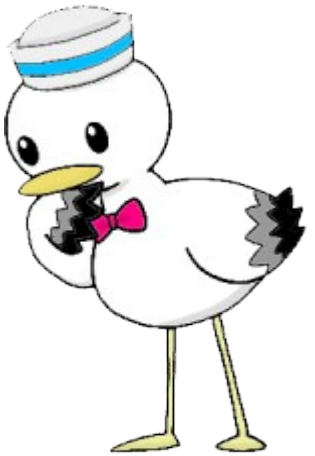
- Urbanization
- Farmland development
- Desertification
- Vegetation / Crop changes



Relationship → **Evaluation**

What is the real problem?

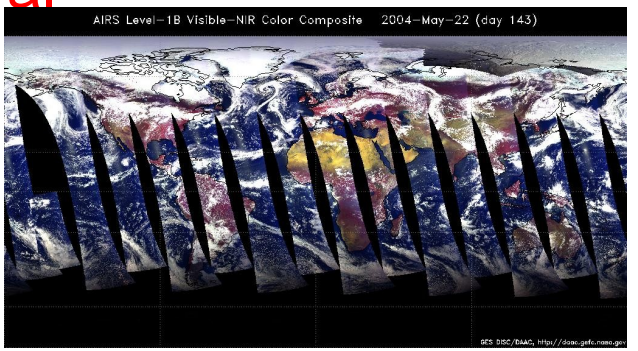
- Inappropriate management
- Collapse of water budget
- Effect of Global Warming
- and so on.



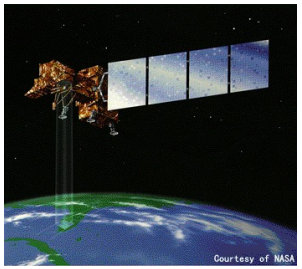
Satellite Remote Sensing

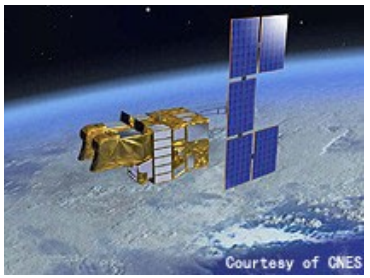
Low Spatial Resolution / Frequent Return Interval

Global Scale
Long Time Trend

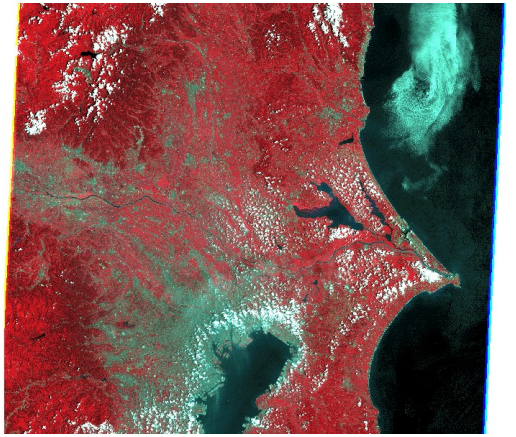


Middle Spatial Resolution / Low Return Interval

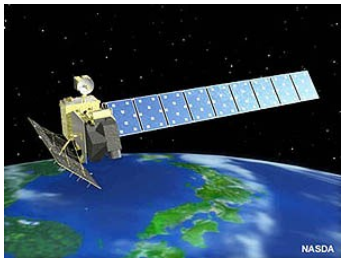




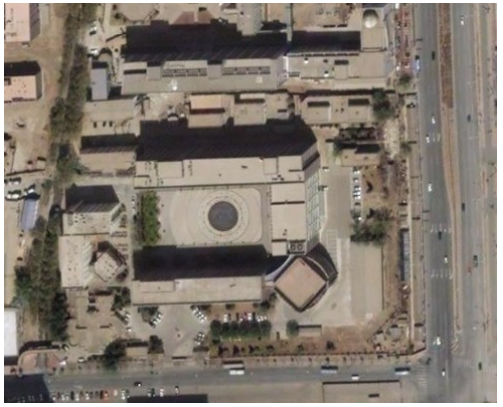
Regional Scale
LUCC



High Spatial Resolution / Low Return Interval



Local Scale
Plot Scale



Low Spatial Resolution / Frequent Return Interval

NOAA/AVHRR	1981
SPOT/VEGETATION	1998
Terra/MODIS	1999

Extraction of the Time Change in ***NDVI***(*Normalized Difference Vegetation Index*) over 20 years is Possible!

What is the significance of the decadal changes in NDVI?

GLOBAL VEGATATION CHANGES BETWEEN 1982 and 2000

As a Framework to Position a Regional Change

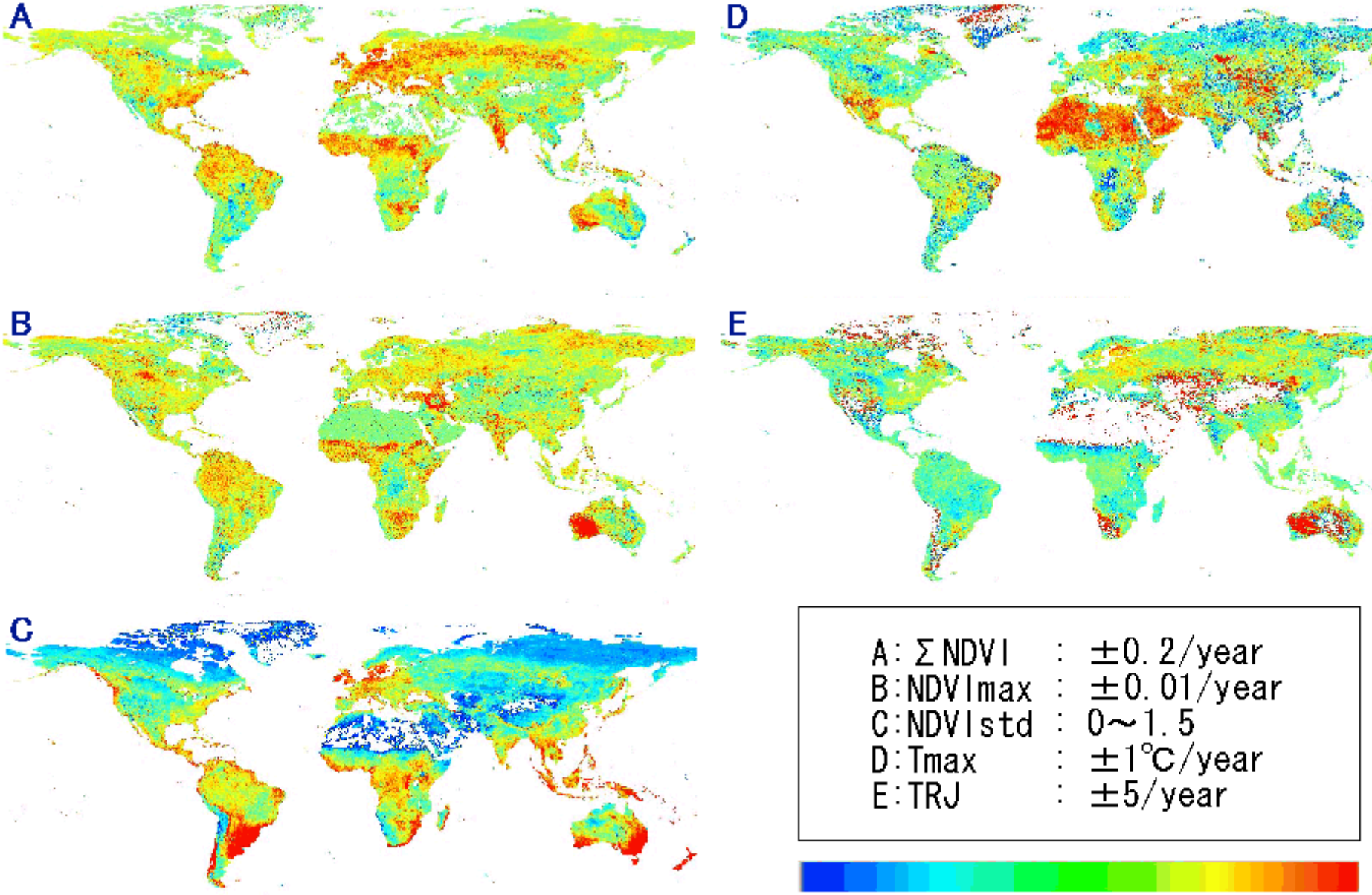
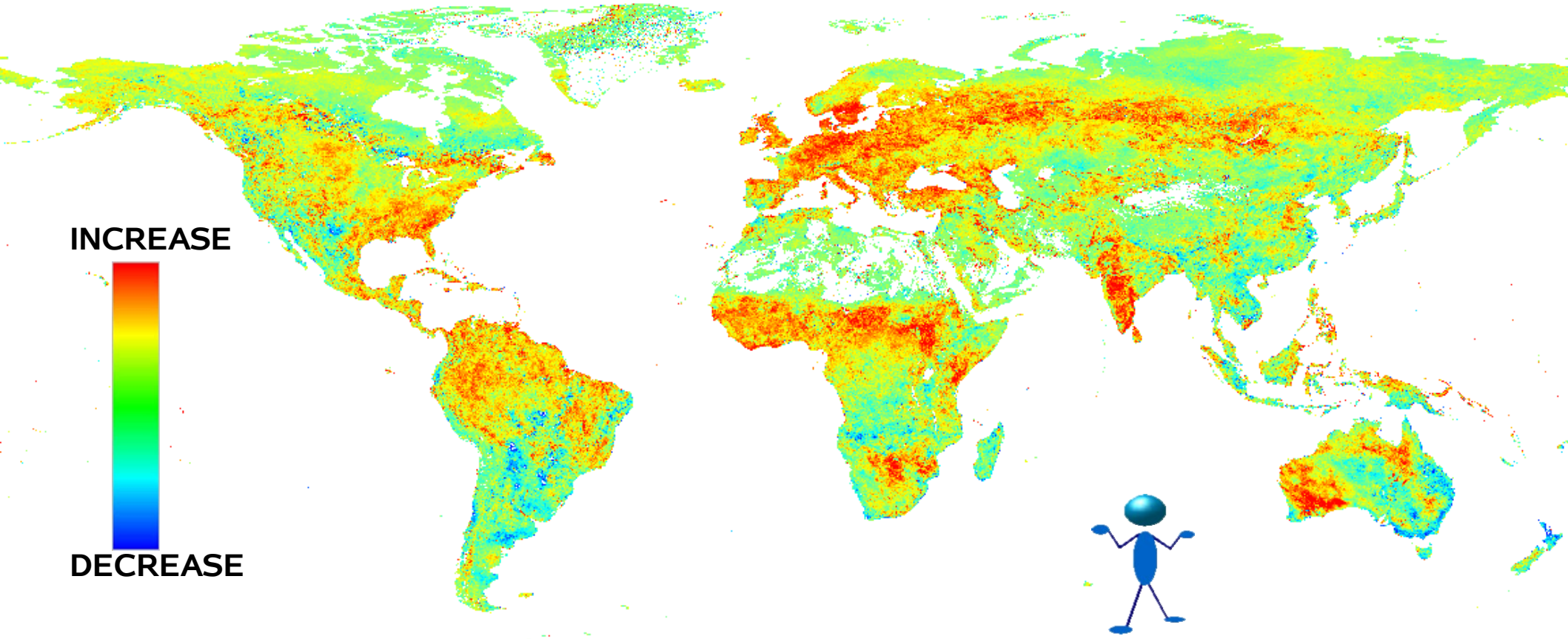


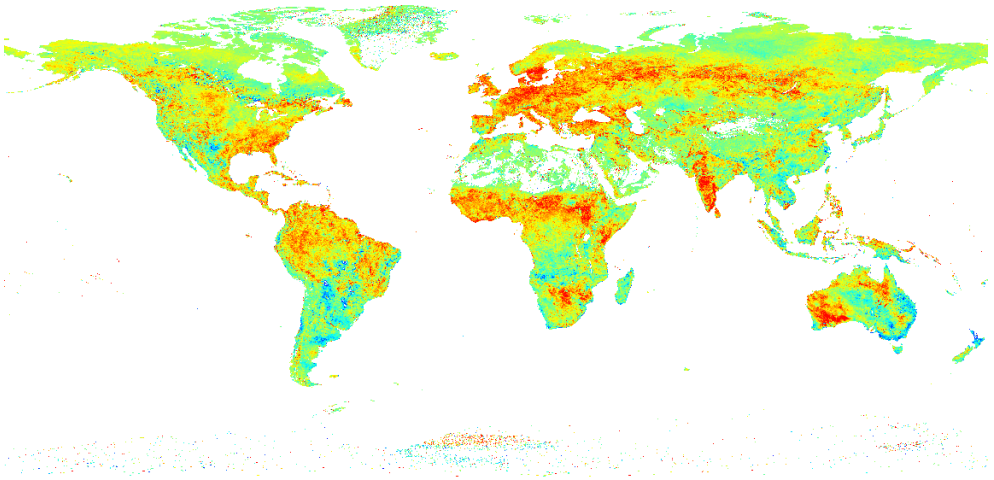
図1 1982年から2000年の間のパラメータのトレンド. A:年間のNDVIの積算値(ΣNDVI)、B:年間の最大NDVI(NDVImax)、C:ΣNDVIの標準偏差(NDVIstd)、D:年間最大地表面温度(Tmax)、E:Ts-NDVI空間における年間の軌跡の傾き(TRJ).

(Kondoh,2004)

Trend of Annual Integrated NDVI(NDVI>0.1) between 1982 and 2000



Decadal vegetation changes after 1982 are recognized around the world



MOST IMPORTANT OUTCOME IN 20th CENTURY

Greening of Boreal Forest

Global warming prompted the early snowmelt and cause extension of growing period

Easy explanation by climatic factor

Easy to apply analytical methods

VEGETATION CHANGES BY HUMAN FACTORS

Difficult to explain by simple analytical methods

Deep understandings to the region is necessary

COMBINE HUMAN AND CLIMATE FACTORS

CLIMATE

Air Temperature
Precipitation
Radiation
...

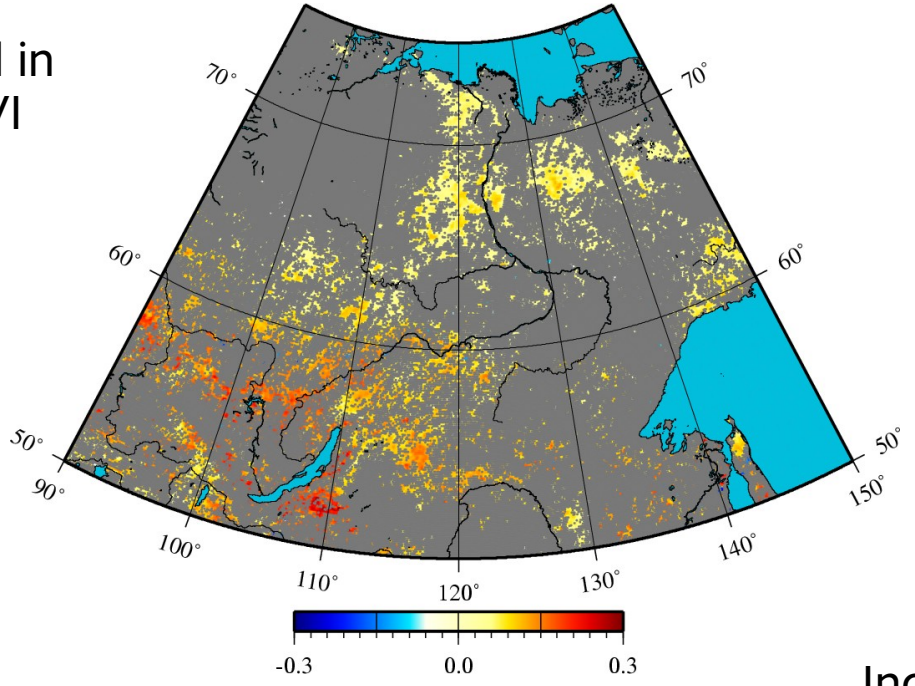
HUMAN

Agriculture
Industry
Urbanization
...

Vegetation Changes in East Siberian Ecotone

-Middle of Boreal and Tundra-

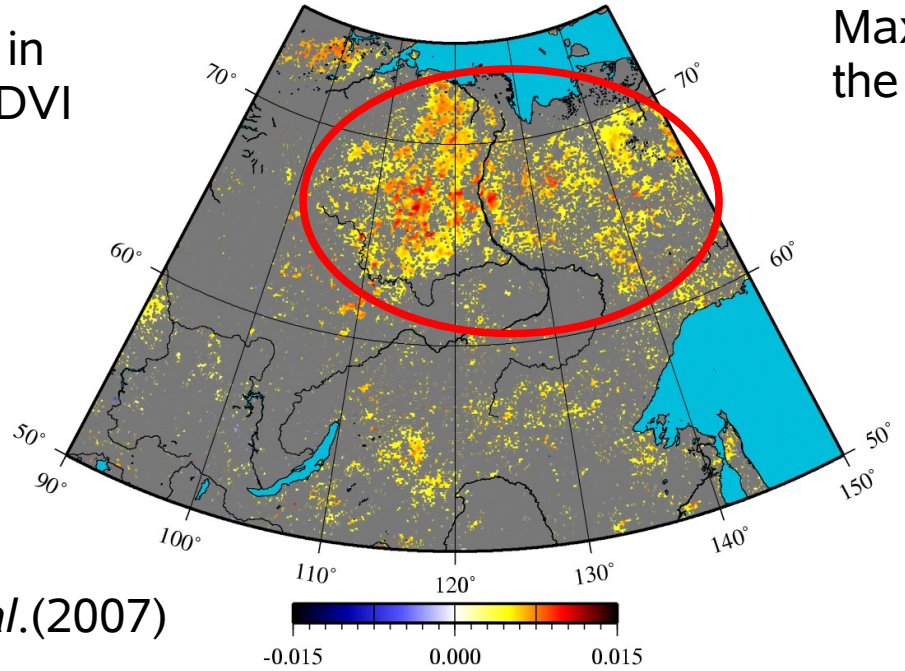
Trend in ΣNDVI



Vegetation changes may lead to the changes in heat and water budget at the surface and further may connect to the changes in water resources!

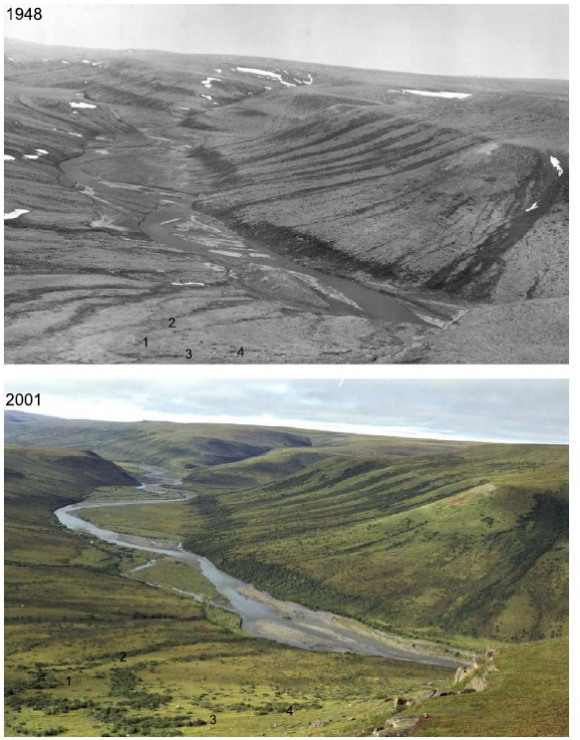
Climate-driven Vegetation Change

Trend in MaxNDVI



Sakai *et al.*(2007)

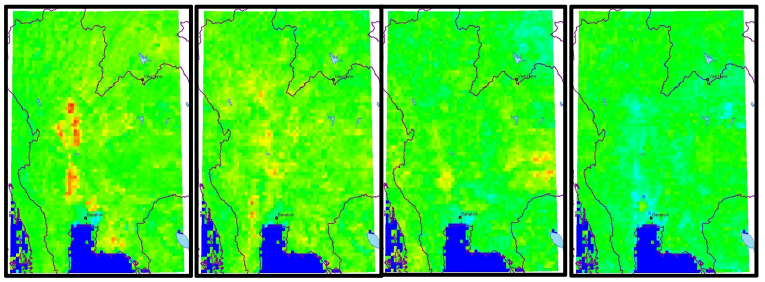
Increase in MaxNDVI at the Ecotone



Stow *et al.*(2004)

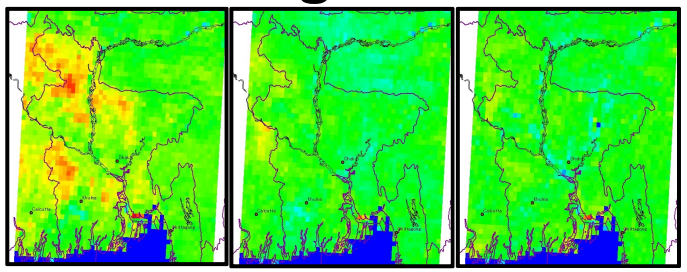
Human-related Vegetation Changes in Continental Scale

Chao Phraya



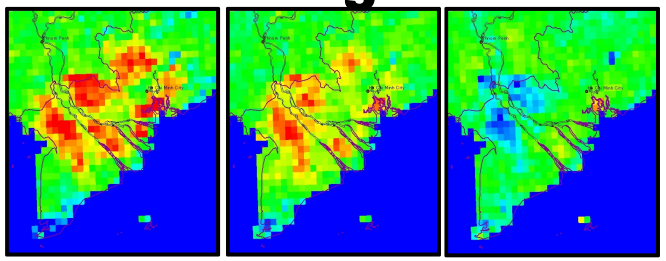
Dry Season (Jan.-Mar.) | Dry Season (Apr.-Jun.) | Rainy Season (Jul.-Sep.) | Rainy Season (Oct.-Dec.)

Bangladesh



Boro Dry Season | Aus Pre-Monsoon | Aman After Flood

Mekong Delta

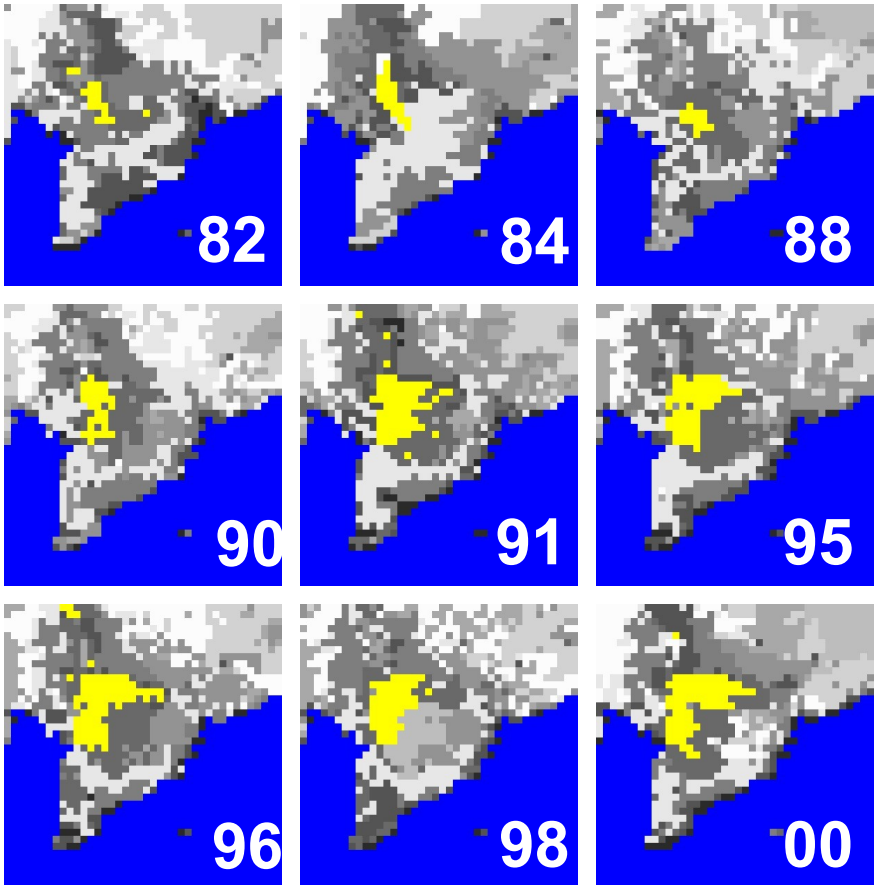


Dry Season | Early Rainy Season | Late Rainy Season

-0.2 +0.2

Increase in Dry Season annual integrated NDVI

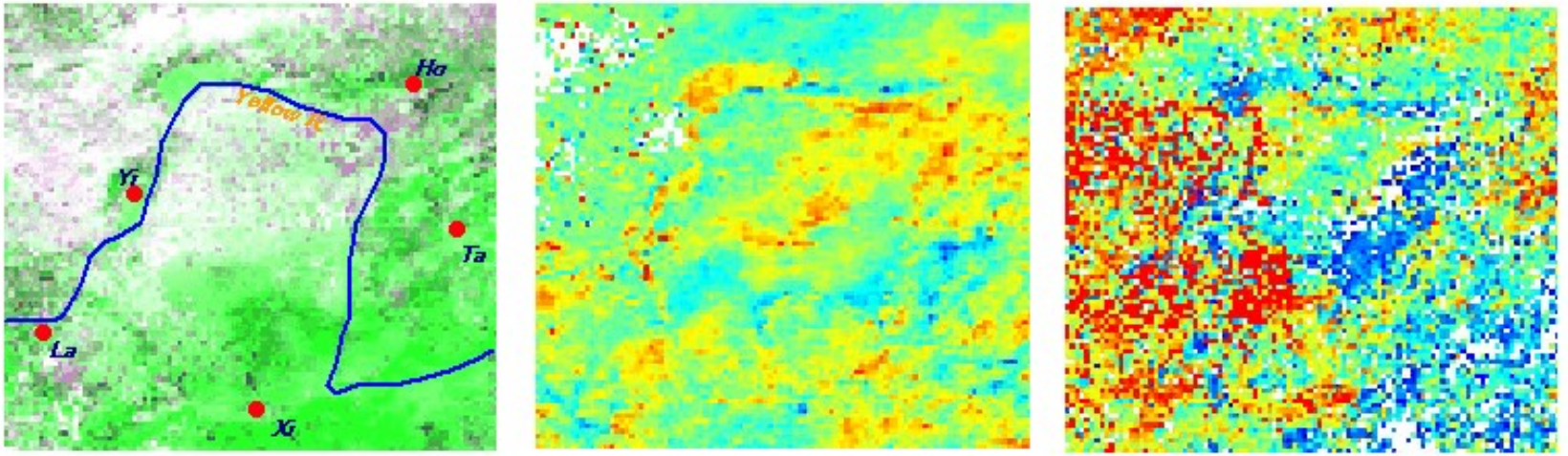
- Increase in Dry Season Paddy
- Green Revolution
- Agronomic Adaptation to the Environment



Increase in two terms paddy crop in Mekong Delta

VEGETATION CHENGES BY HUMAN FACTOR

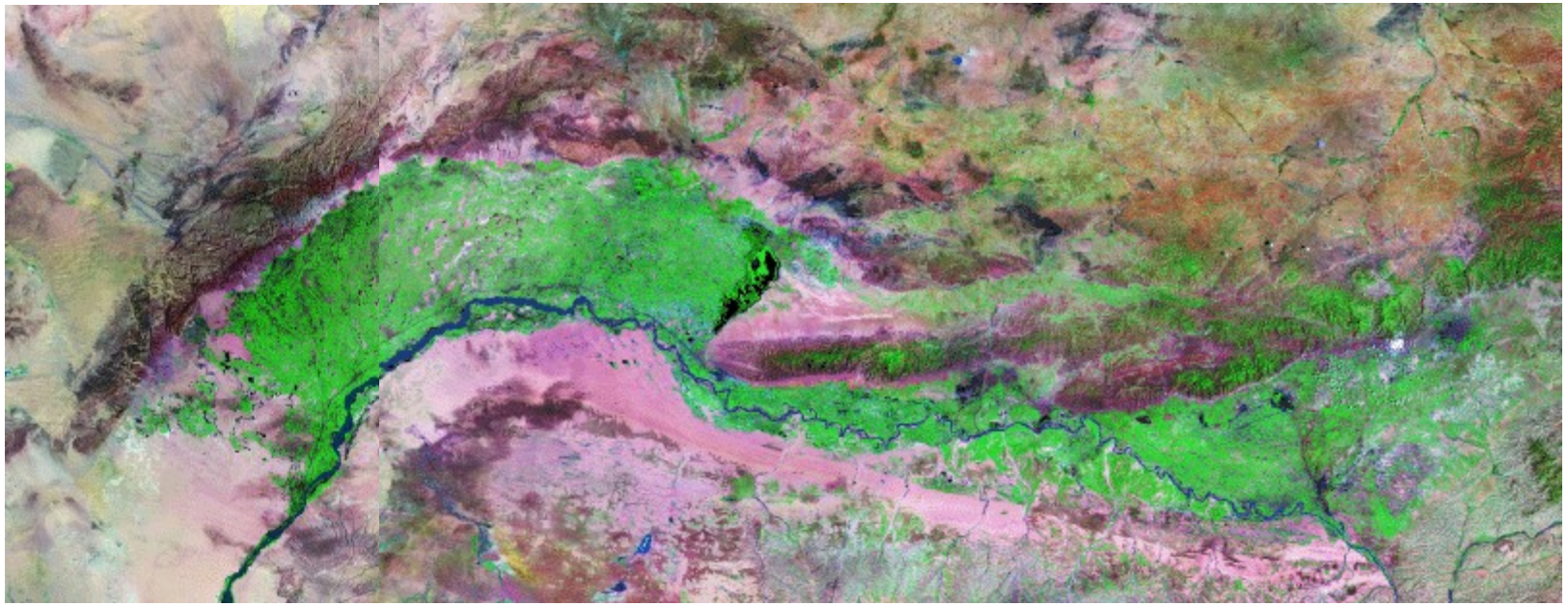
Chinese Case: Middle Reach of the Yellow River



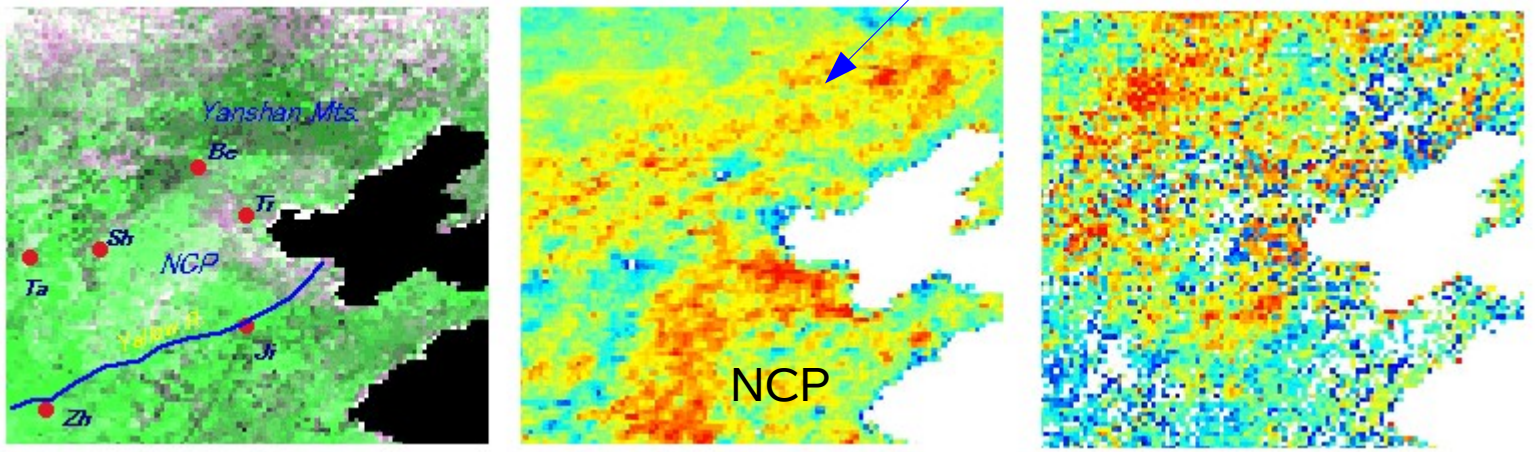
(LEFT) False color image of NOAA/AVHRR

(MIDDLE) 19 years Trend of annual integrated NDVI

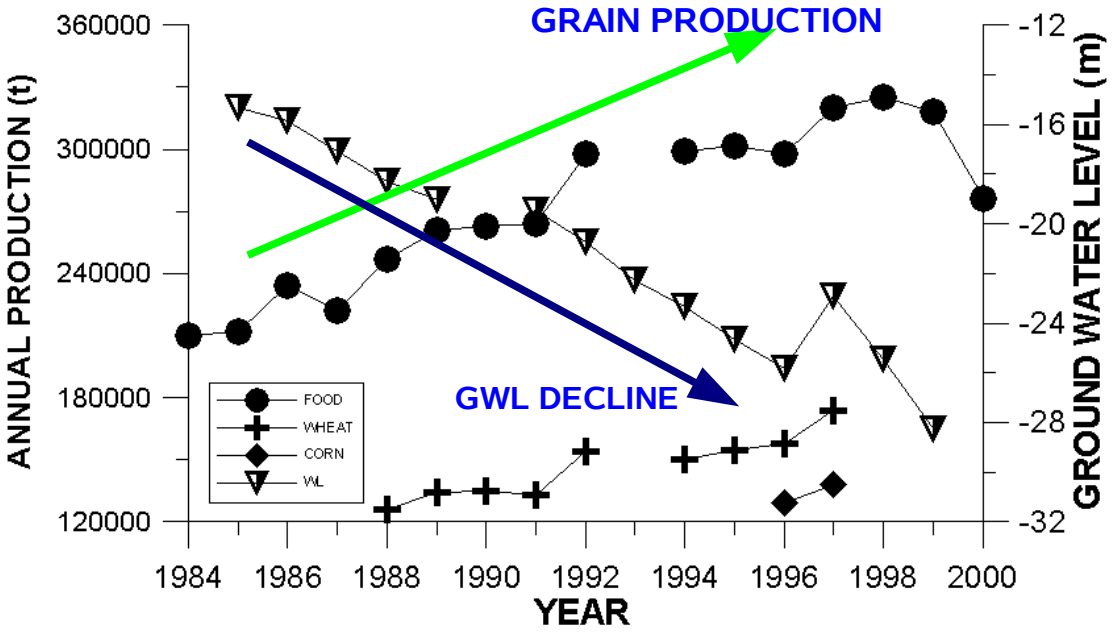
(RIGHT) 19 years trend of annual maximum TBB



NORTH CHINA PLAIN



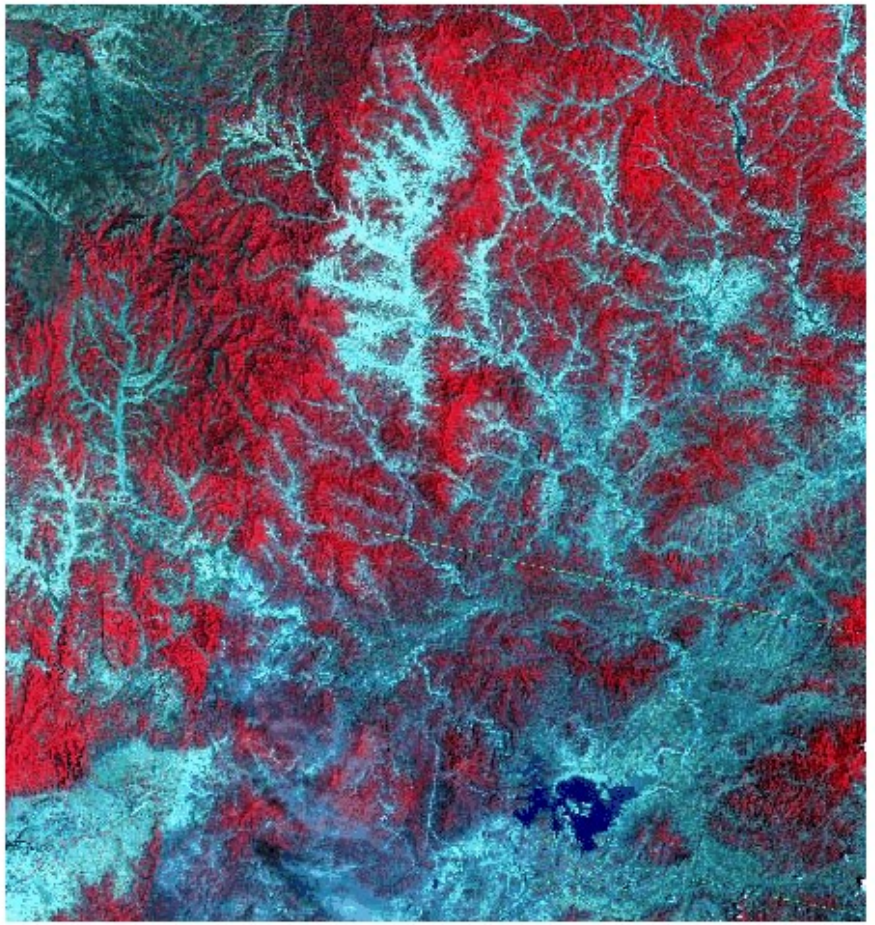
(LEFT) False color image of NOAA/AVHRR
(MIDDLE) 19 years Trend of annual integrated NDVI
(RIGHT) 19 years trend of annual maximum TBB

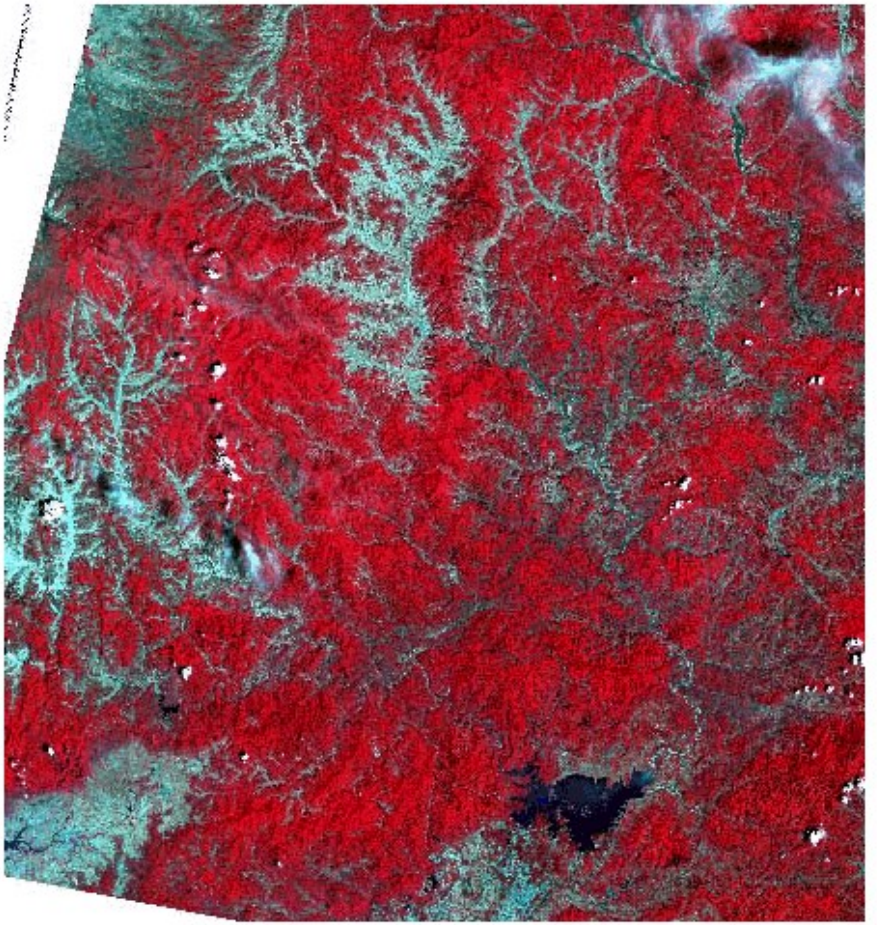


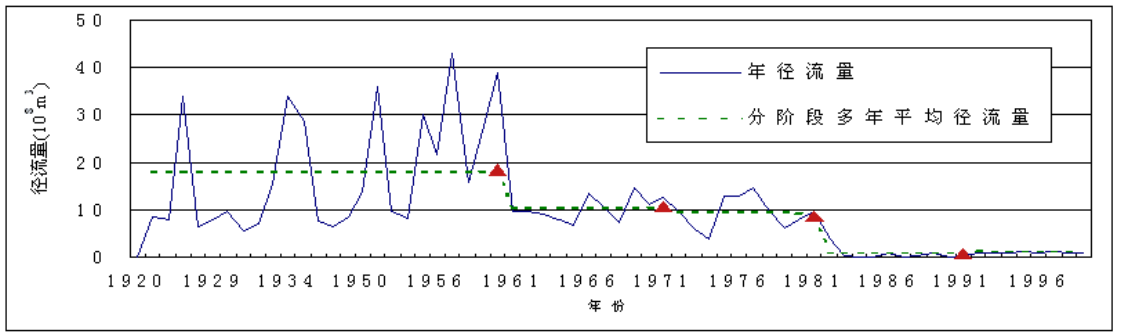
Grain production and groundwater level at Luancheng Station

Vegetation change(including agriculture) by human factors influence on water resource management.

Forest Restoration in Miyung Watershed by Middle-sized Satellite from 1976.6 to 1999.6







Five Periods of Annual Runoff in Chaobaihe River

What is the cause of inflow reduction?

- Evapotranspiration increase
- Increase in water usage
- Climatic change

Forest is good or bad for water conservation?

What is the relationship between Forest recovery and water resources?

Priority of forest & water conservation(Tsukamoto, 1998)

(1) Conservation of soil
Yanshan forest
(2) Conservation of forest

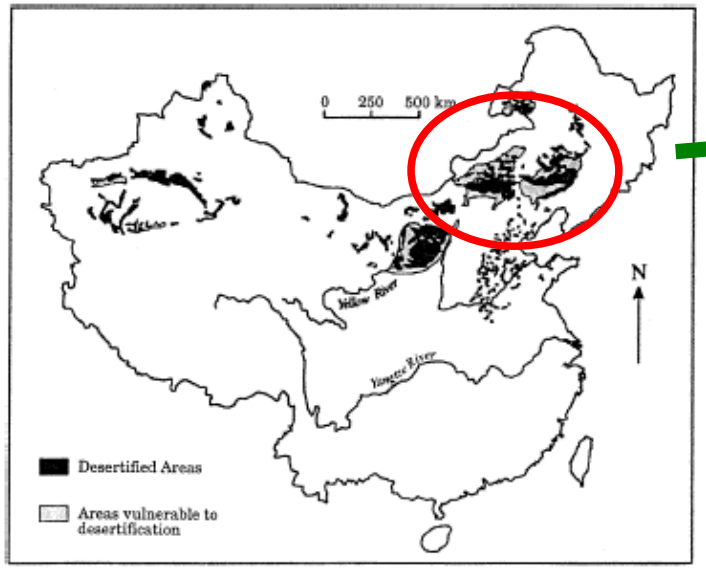
(3) Conservation of water
Japanese forest

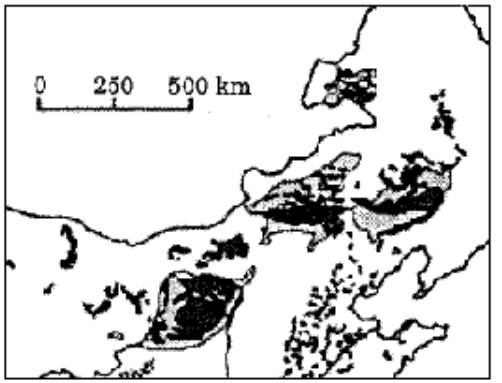
Combination between RS techniques and knowledge of forest sciences

SCALE-ISSUE *Desertification*

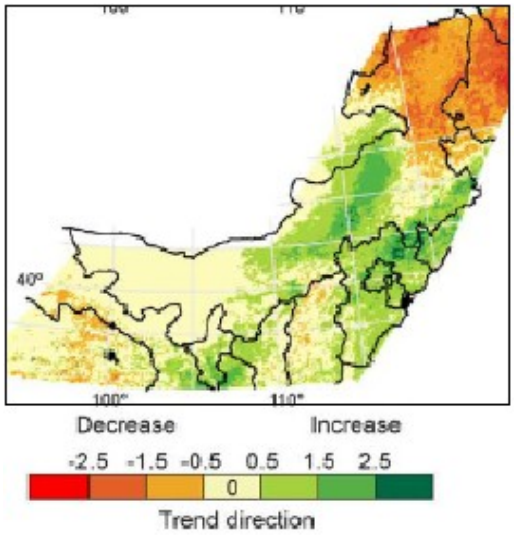
- Important issue relating water resource development & management -

A Case in Hortin sandy district





Desertified area in China
Zha and Gao (1997)



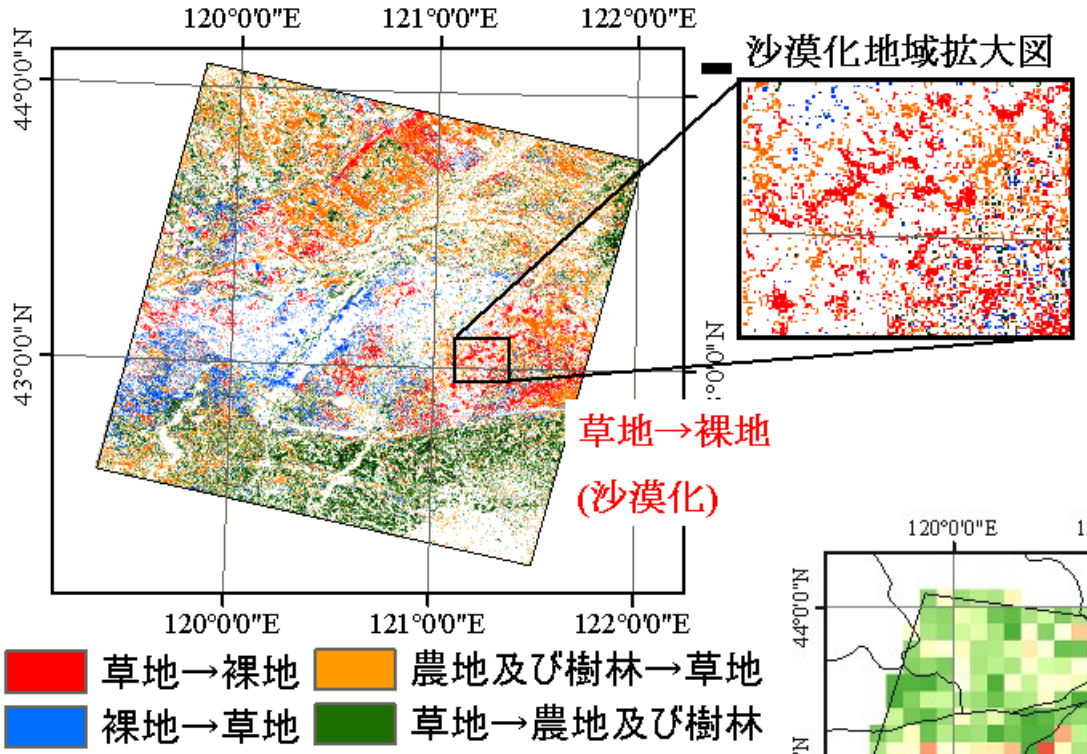
Brogaard *et al*. (2005)

PARADOX

NPP Increase in desertified area?

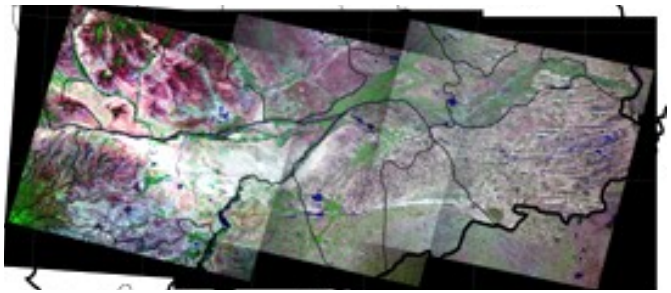
Patchy distribution of degraded terrain and greened land

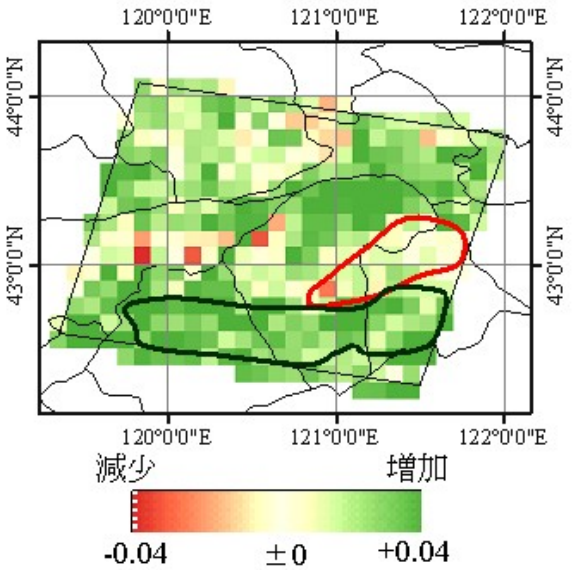
-Scale effect between coarse and fine resolution images

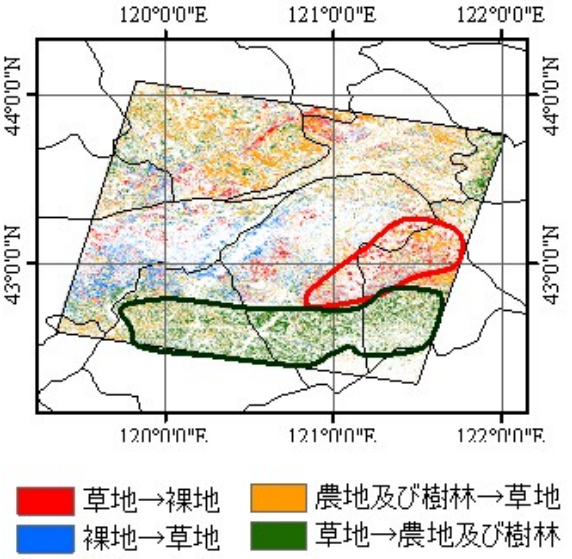


LUCC changes between 1986 and 2000 by LANDSAT TM/ETM+

RED: degraded land





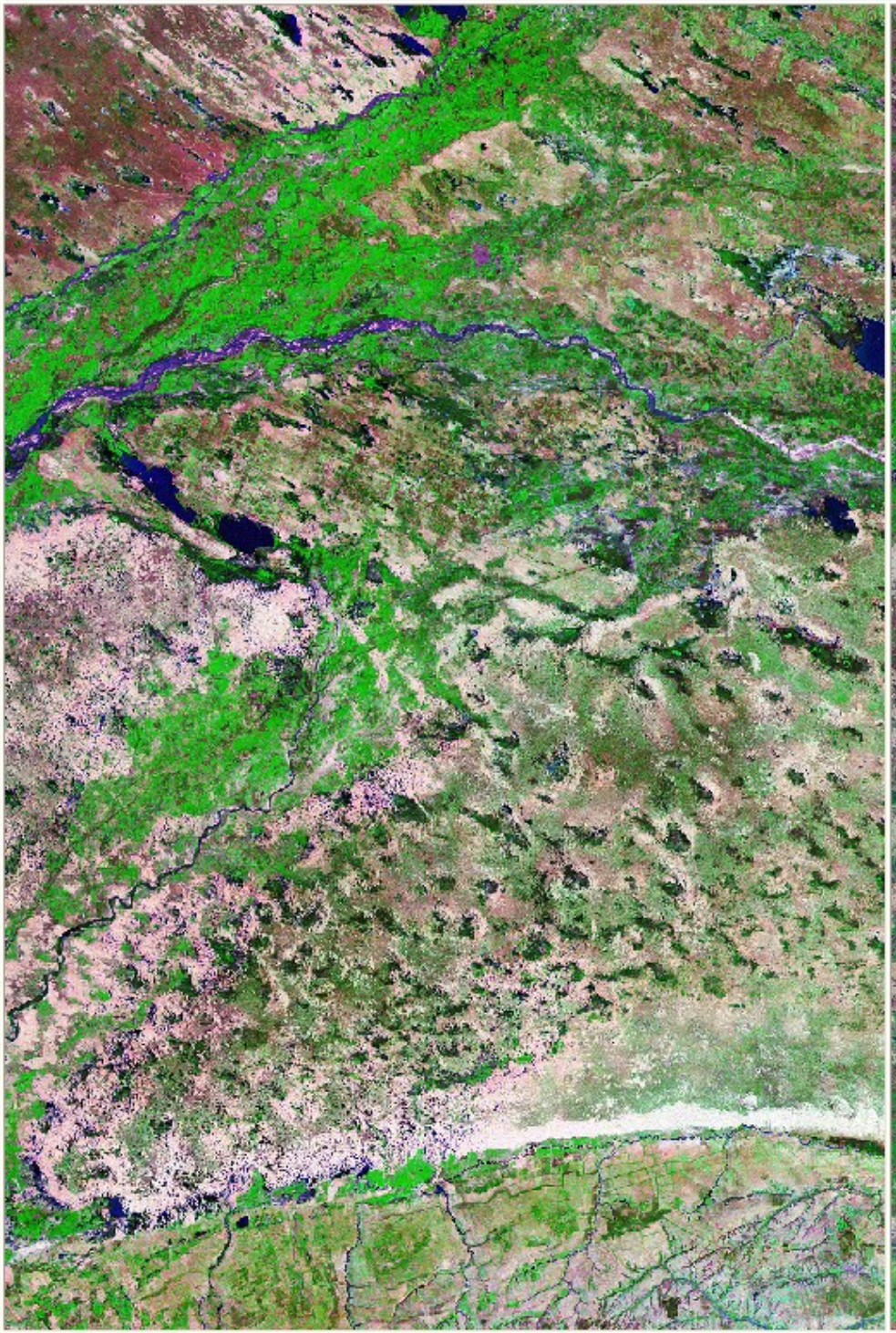


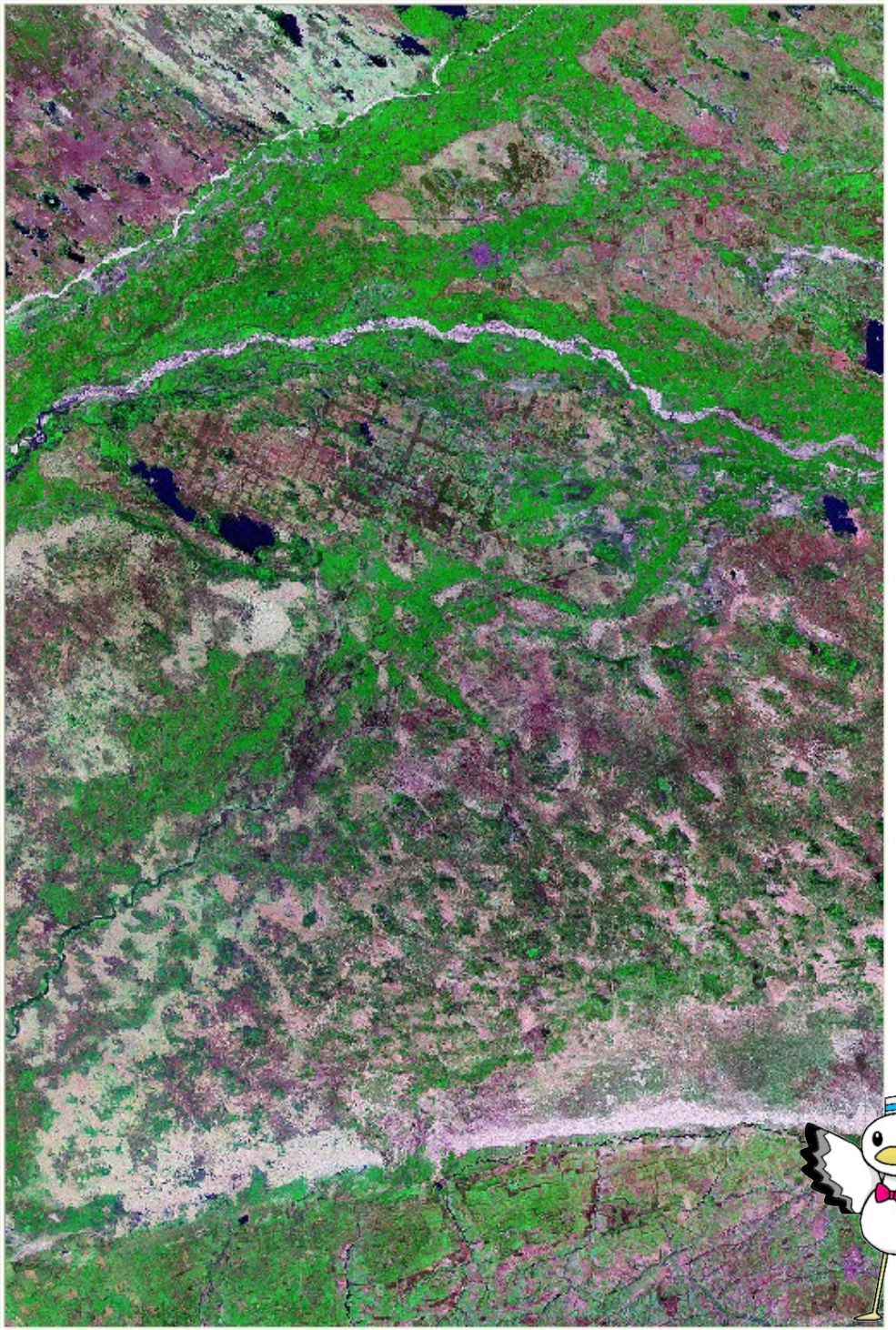
NOAA/AVHRR

LANDSAT/ETM+

(Osada MS 2007)

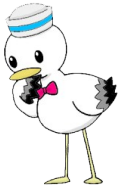
NASA Geocover TM Mosaic Circa 1990(left) & Circa 2000(right)





Middle to high spatial resolution satellite image browse system

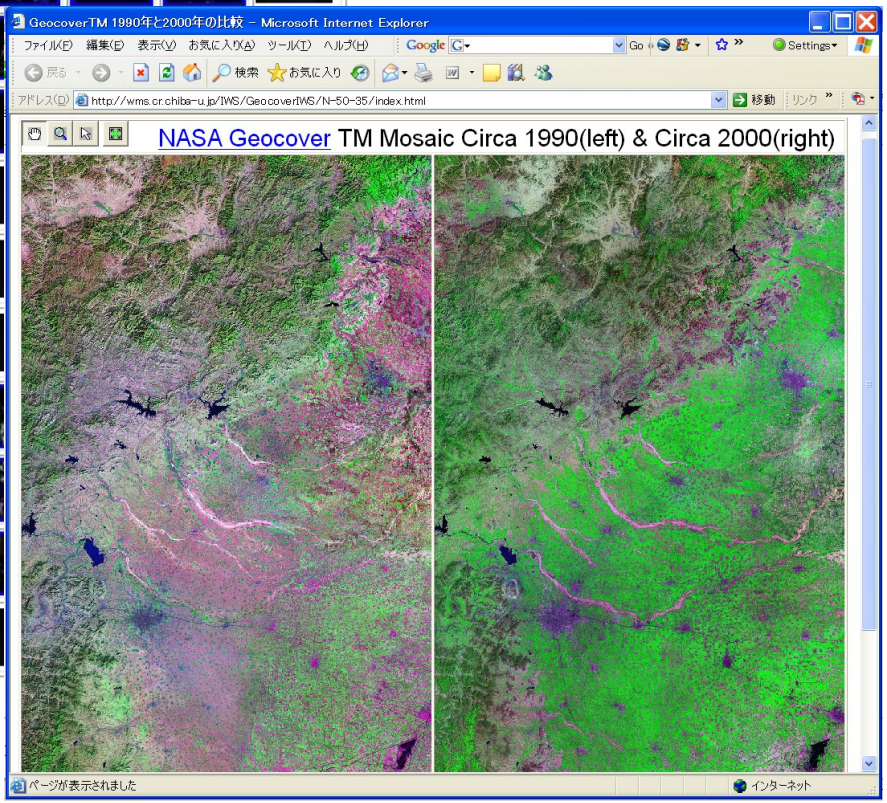
Collaboration between RS technique and field knowledge



UTM ZONE /LATITUDE	42	43	44	45	46	47	48	49	50	51	52	53	54	55
N-50														
N-45														
N-40														
N-35														
N-30														
N-25														
N-20														
N-15														
N-10														
N-05														
N-00														
S-00														
S-05														
S-10														

WEB 2.0

Two-way communication between RS and



http://dbx.cr.chiba-u.jp/
http://wms.cr.chiba-u.jp/IWS/GeocoverIWS/

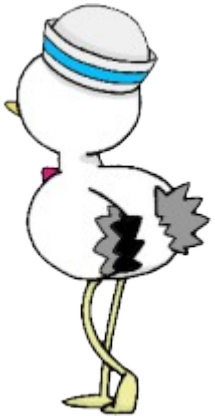
A Usage of Satellite Images

(1)Extraction of the Changes in Time and Space Domain

(2)Analysis for the Cause of the Change

Interdisciplinary Knowledge, Field Experience are necessary for image interpretation.

(3)Find the True Problem



Conclusion

Principle-based Science 真理探究型科学

Extraction of physical parameters from RS
Input to the model
Evaluation / Prediction

Relationship-based Science 関係性探究型科学

Recognition of environmental changes from image interpretation
Understandings of the actual condition combined with field research
Recognition of the true problem
Key to the sutable future - How we live?

Collaboration of various field
Inter-Disciplinary study