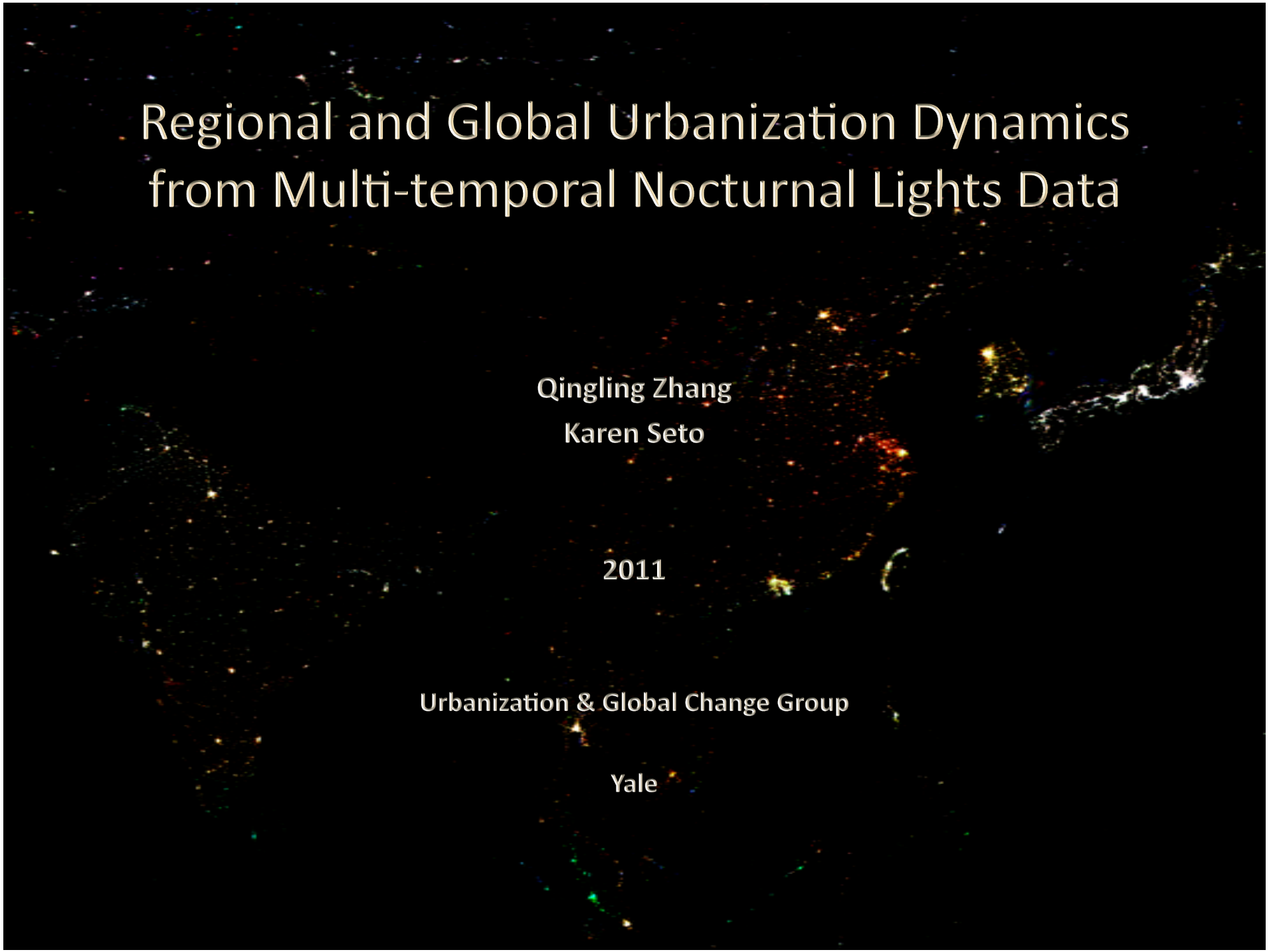

# Regional and Global Urbanization Dynamics from Multi-temporal Nocturnal Lights Data

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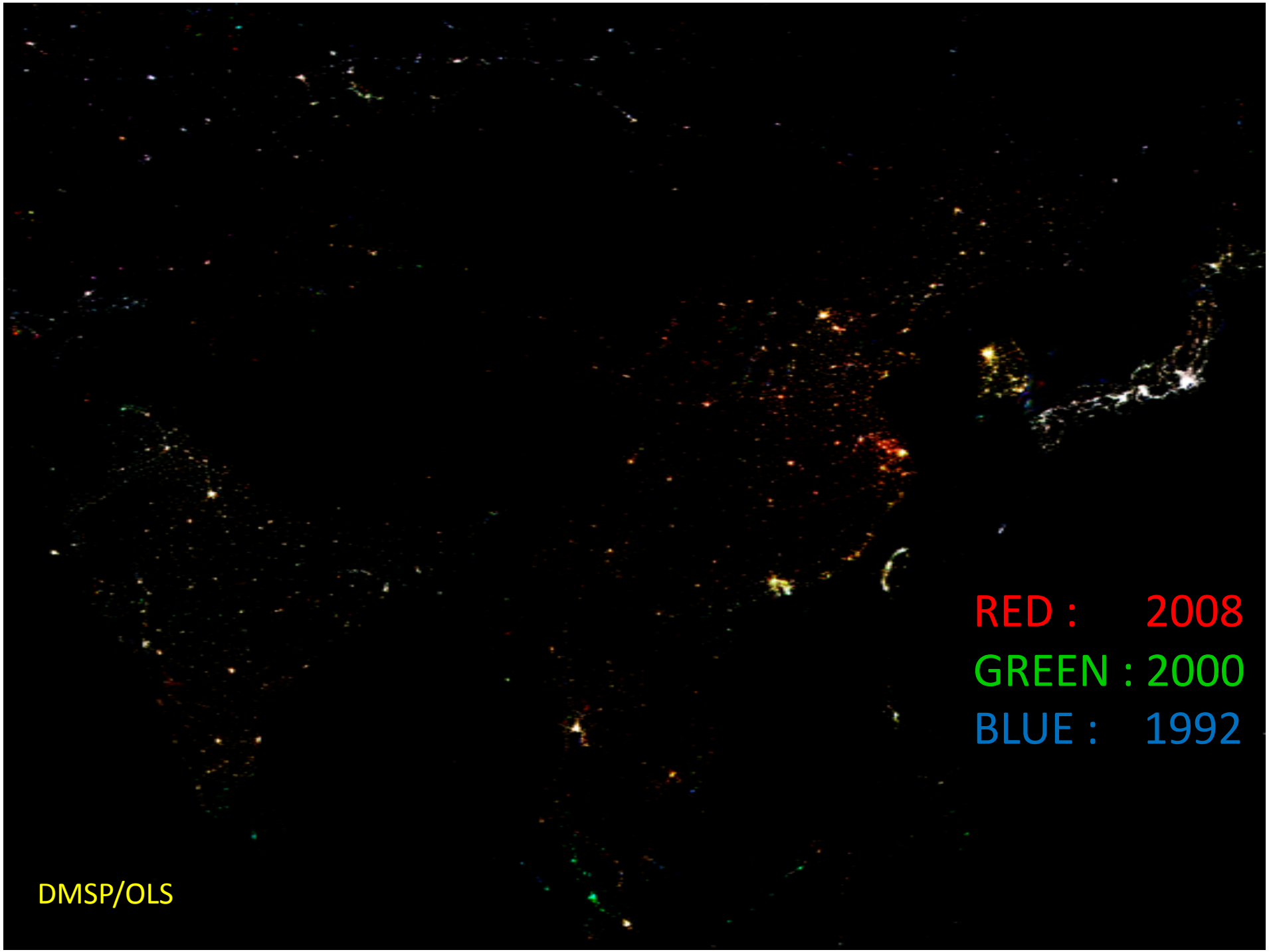
2011

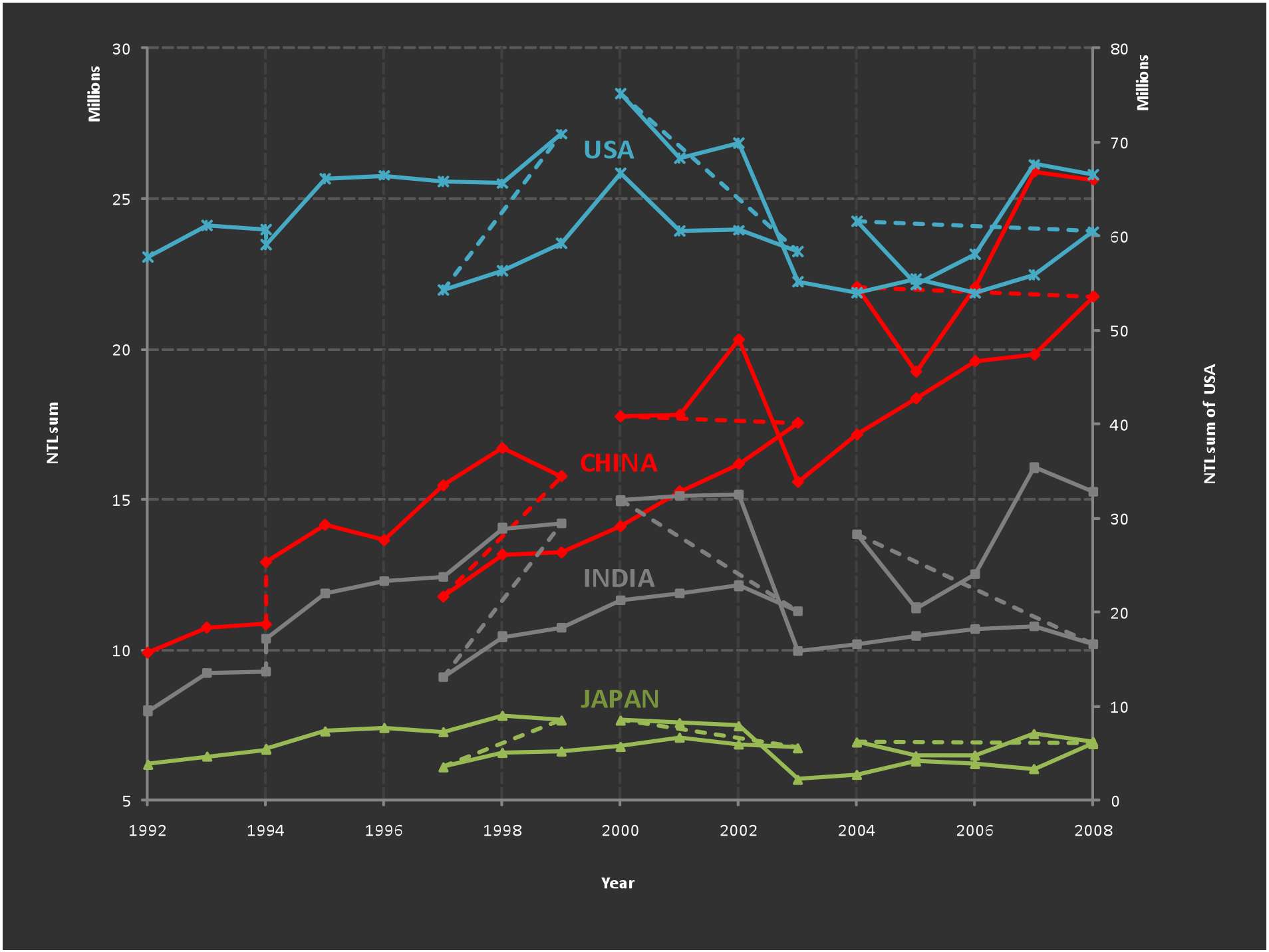
Urbanization & Global Change Group

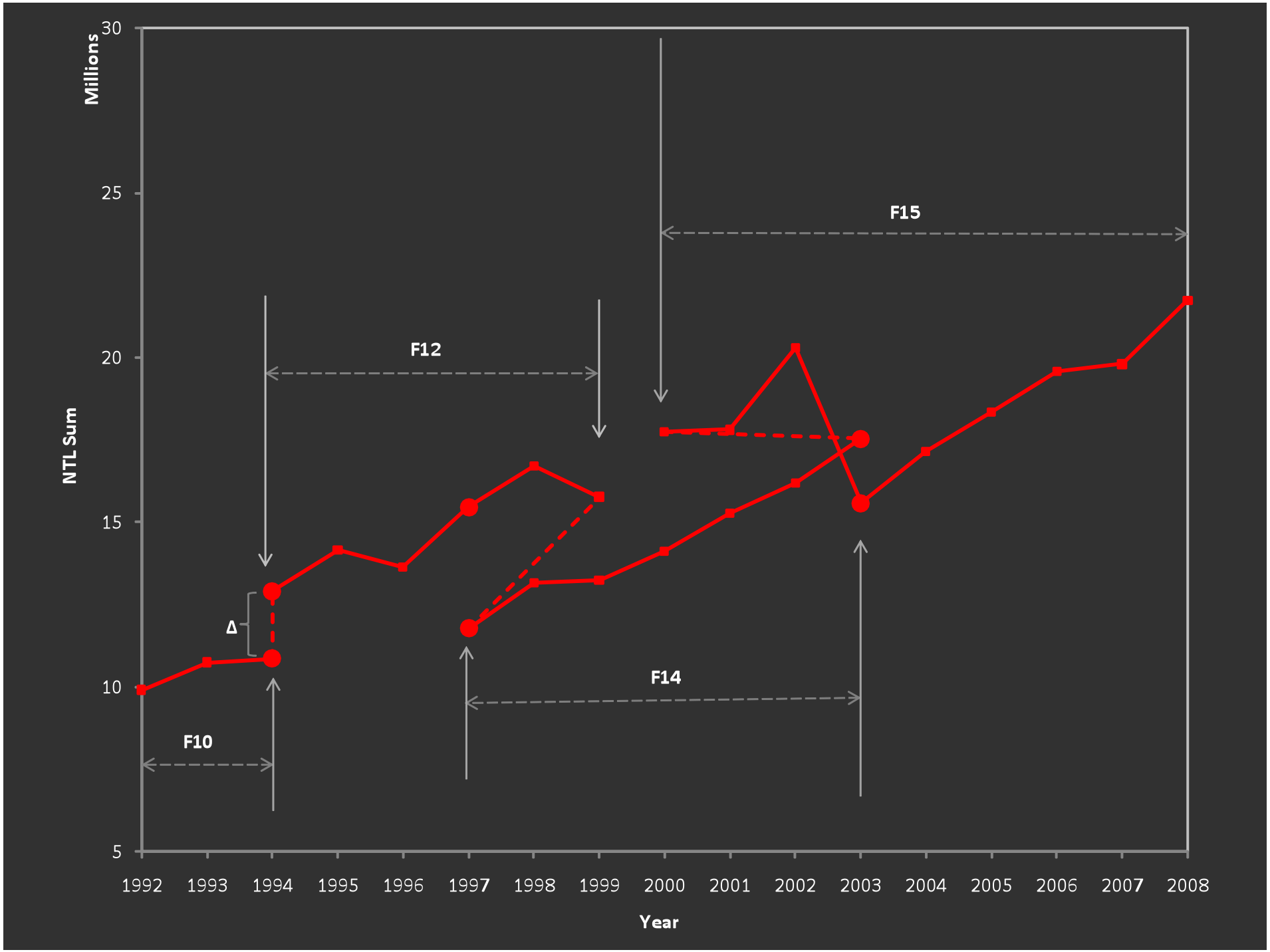
Yale


RED : 2008
GREEN : 2000
BLUE : 1992
DMSP/OLS

DMSP/OLS

Inter-sensor calibration

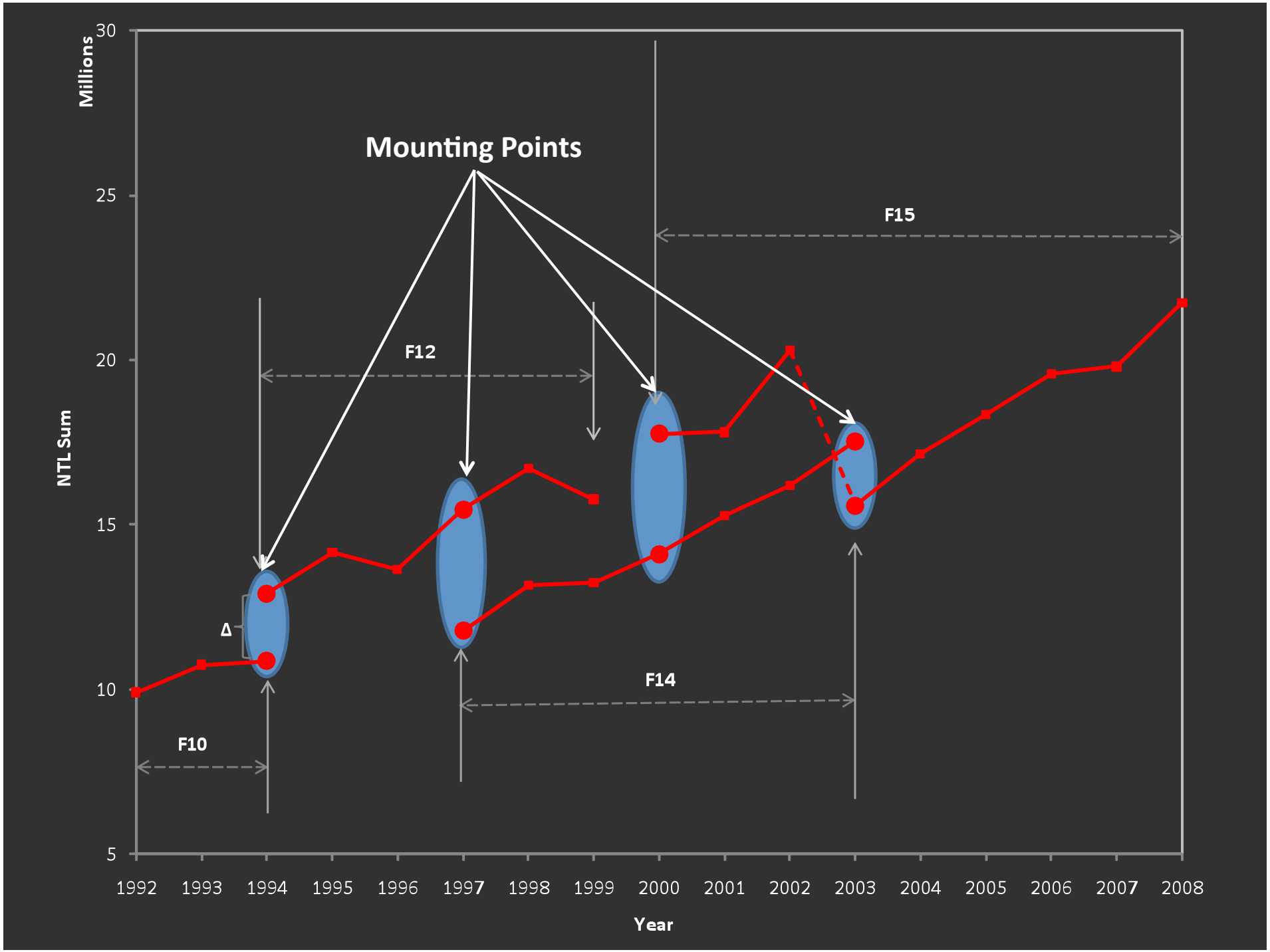

Millions
NTL sum
30
25
20
15
10
5
Millions
NTL sum of USA
80
70
60
50
40
30
20
10
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year
USA
CHINA
INDIA
JAPAN

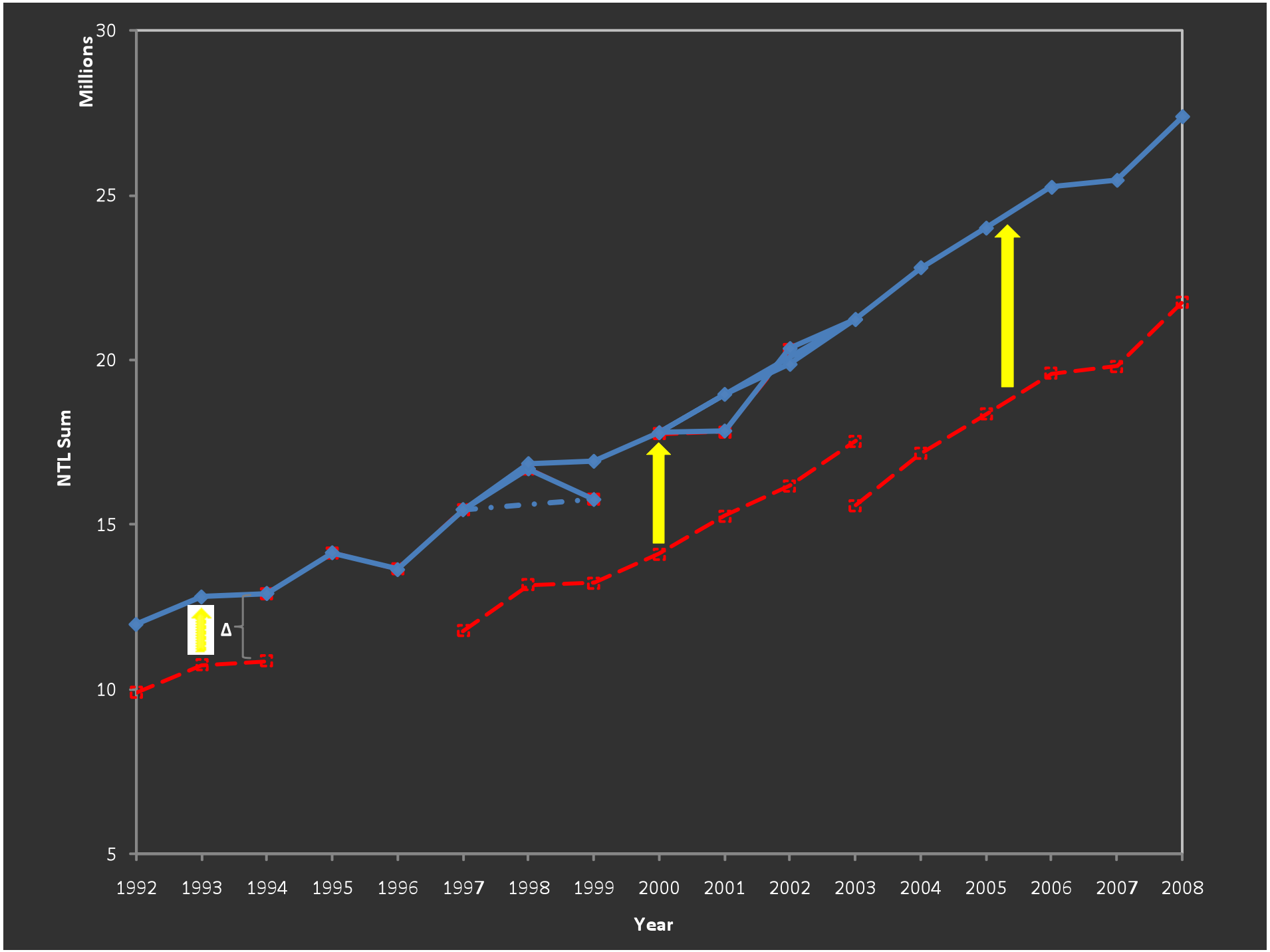

Millions
30
25
20
15
10
5
NTL Sum
F15
F12
Δ
F14
F10
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

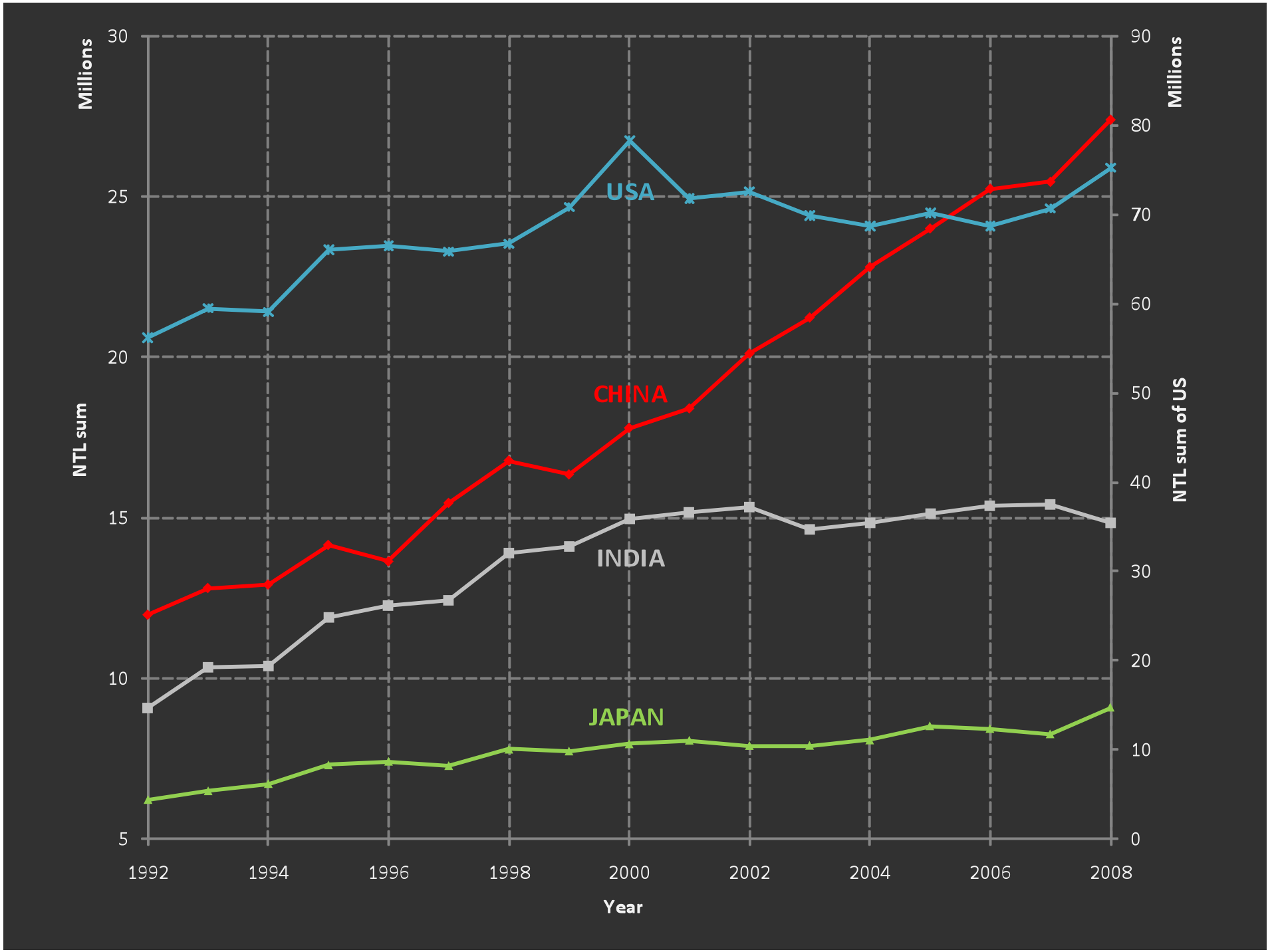
… the digital number (DN) values are not strictly comparable from one year to the next.

--- http://www.ngdc.noaa.gov/dmsp/readme_v4.txt

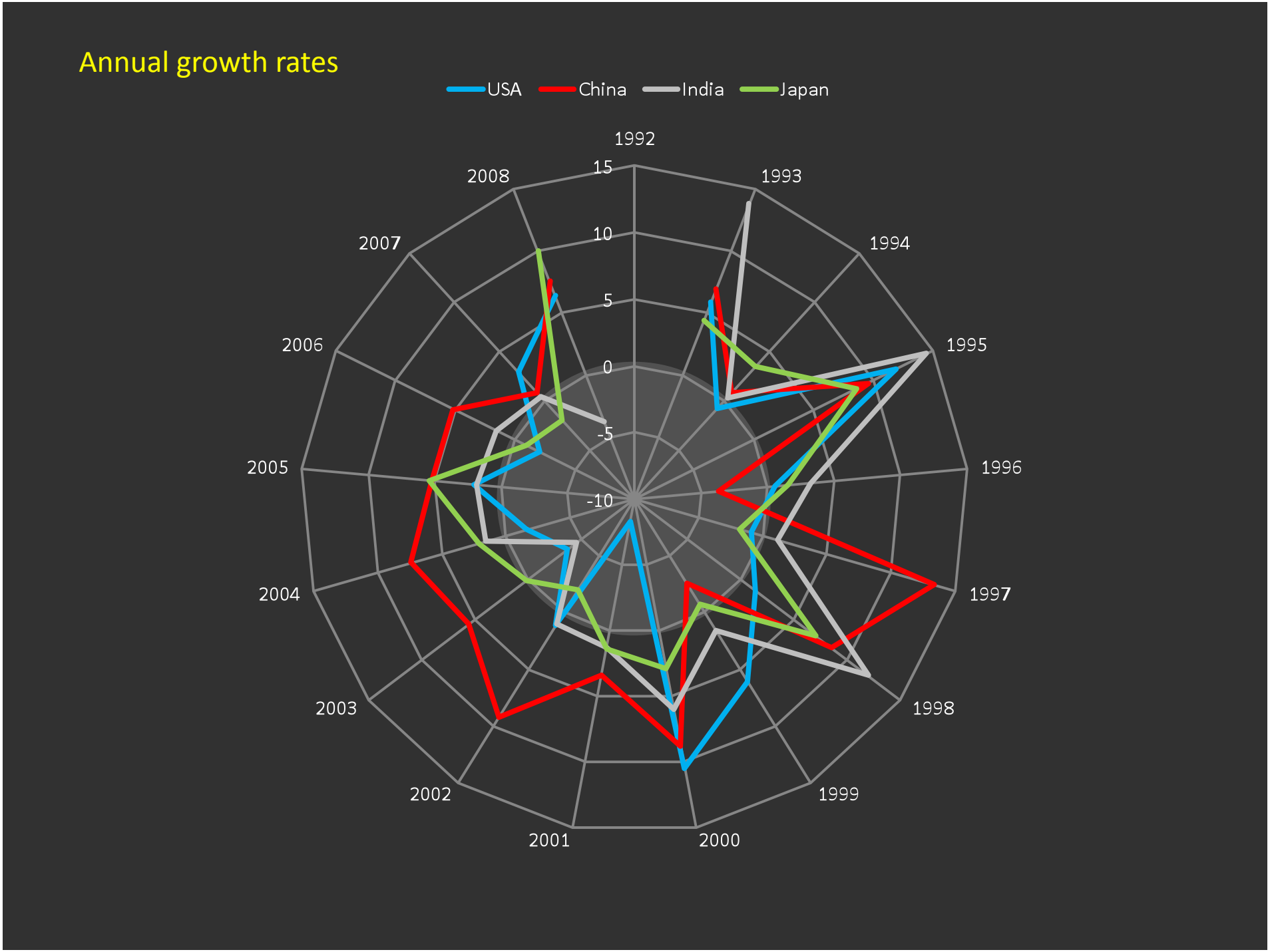
Country level calibration


Millions
30
25
20
15
10
5
NTL Sum
Mounting Points
F15
F12
Δ
F14
F10
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year


Millions
30
25
20
15
10
5
NTL Sum
Δ
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year


Millions
30
25
20
15
10
5
NTL sum
90
80
70
60
50
40
30
20
10
0
Millions
NTL sum of US
USA
CHINA
INDIA
JAPAN
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year

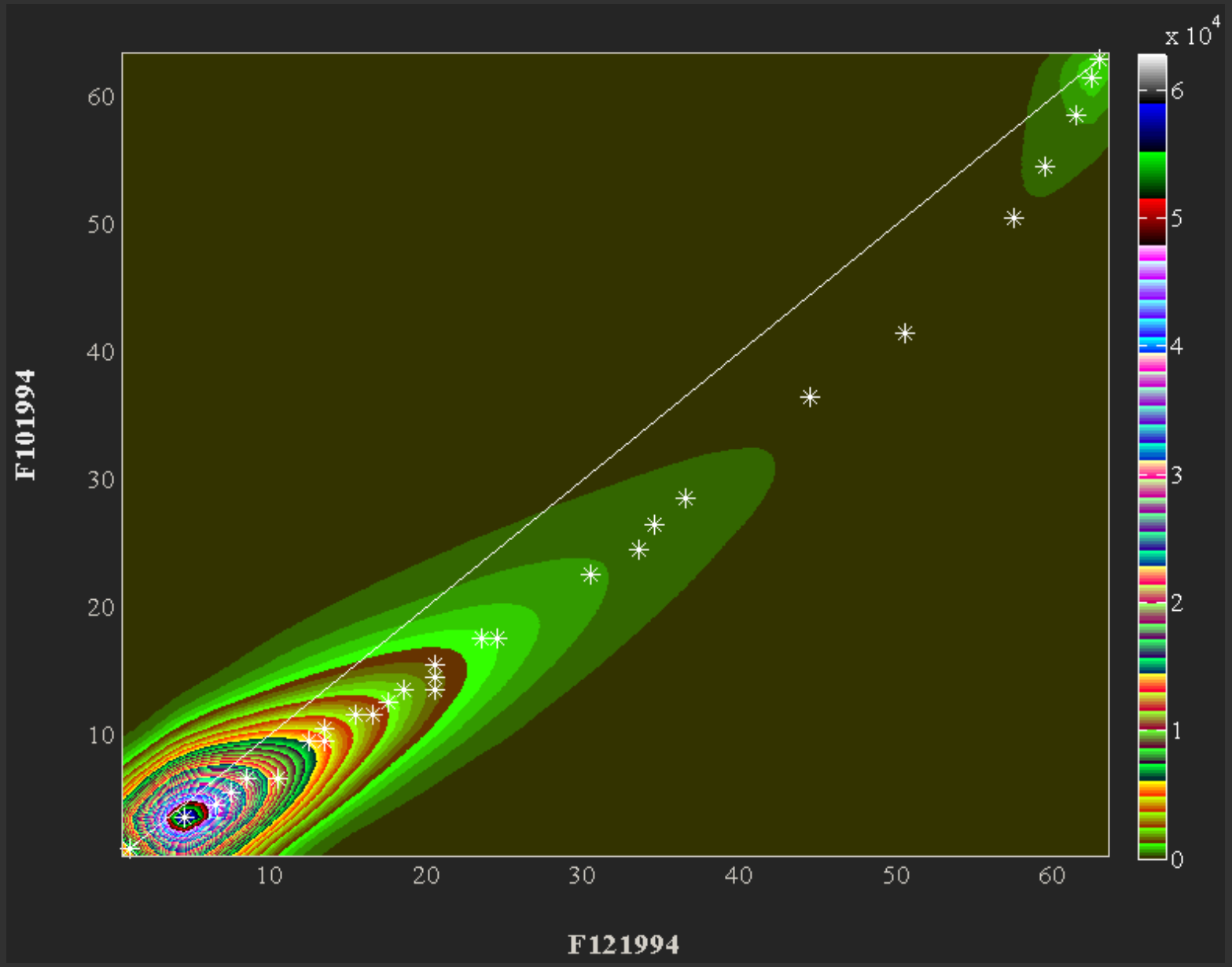
## Annual growth rates



Pixel level calibration:

Modified Ridge method

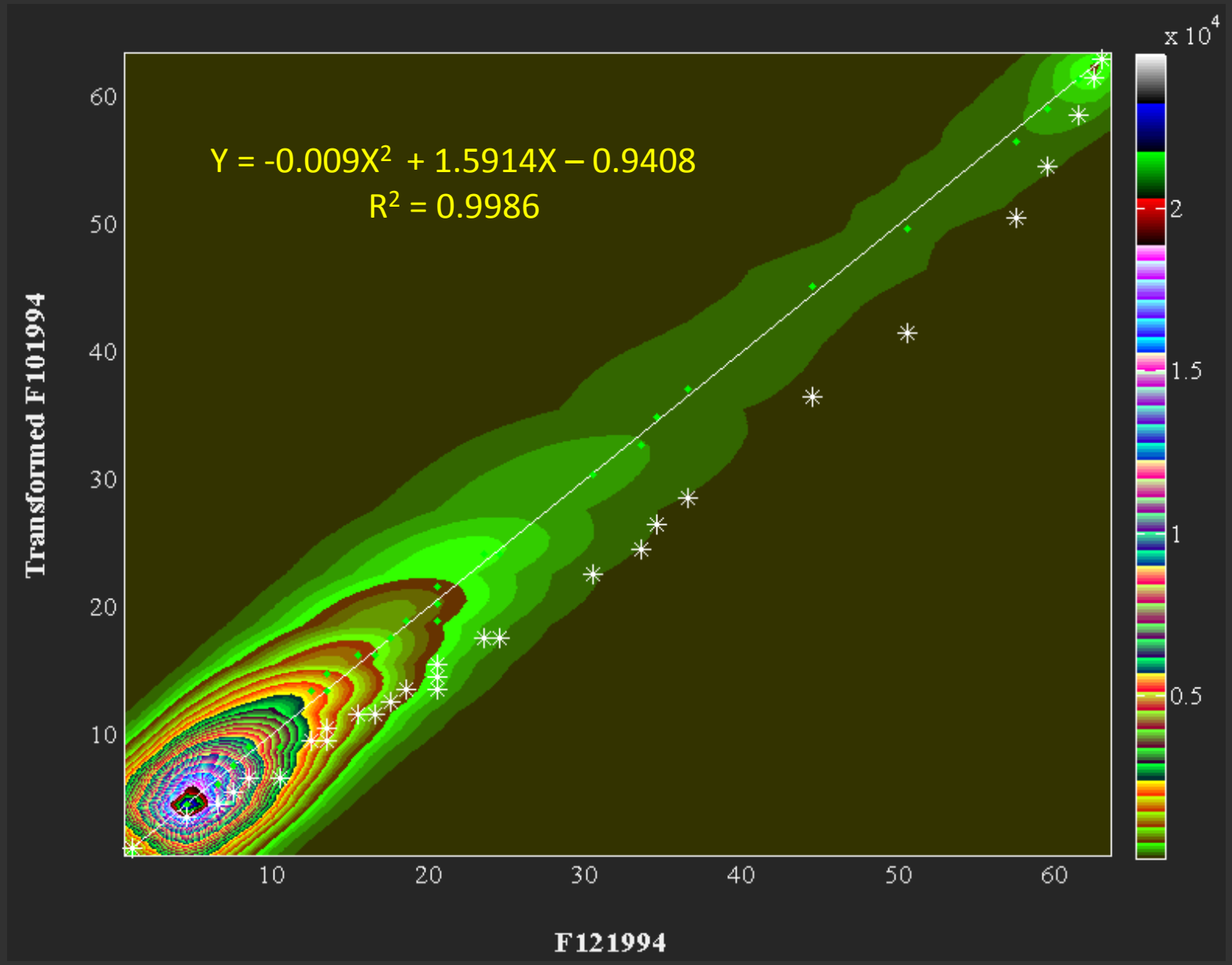
# Density Scattergram



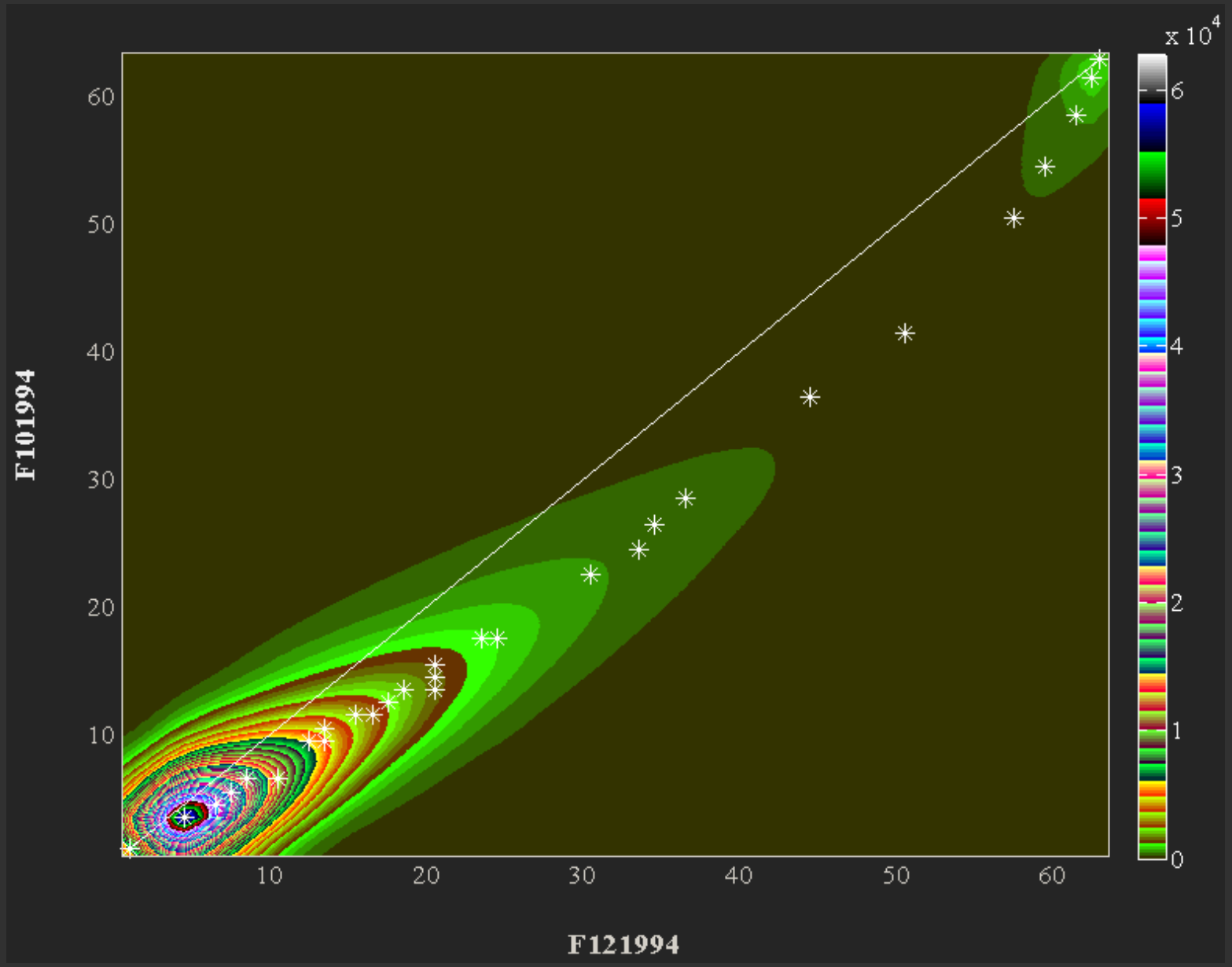
# A ridge in the real world

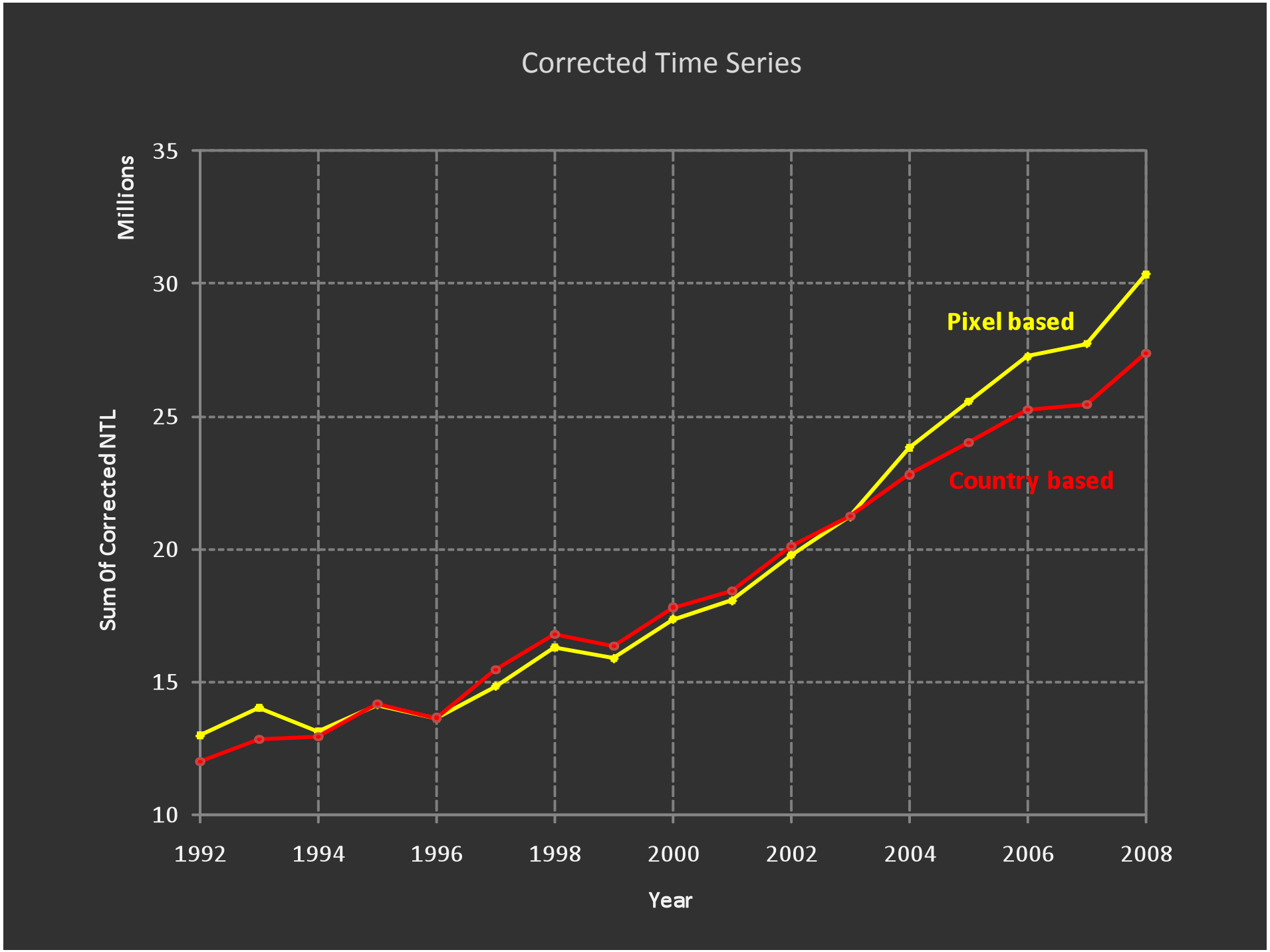
http://www.winddrinkers.org/BRR/BridgerRidge.html

# Adjusted Ridge



# Density Scattergram




Corrected Time Series
Millions
Sum Of Corrected NTL
35
30
25
20
15
10
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year
Pixel based
Country based

# Urbanization Clusters – Hotspot Analysis with LISA

## LISA -- Local Indicators of Spatial Association

> Spatial autocorrelation: Tobler's first law of geography

$$I_i = \frac{Z_i}{m_2} \sum_j^N W_{ij} Z_j$$

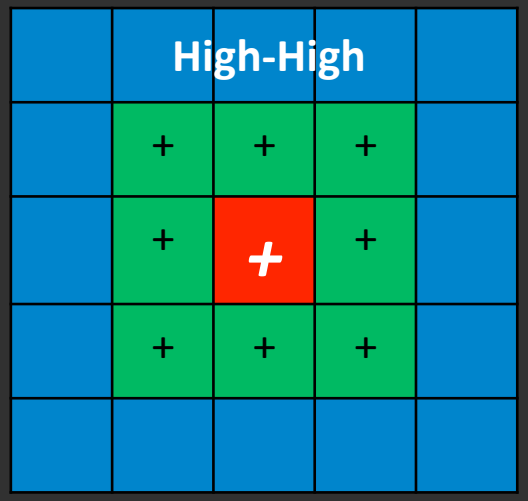
$Z_i$ : distance from the global mean;
$W_{ij}$: matrix of weight;

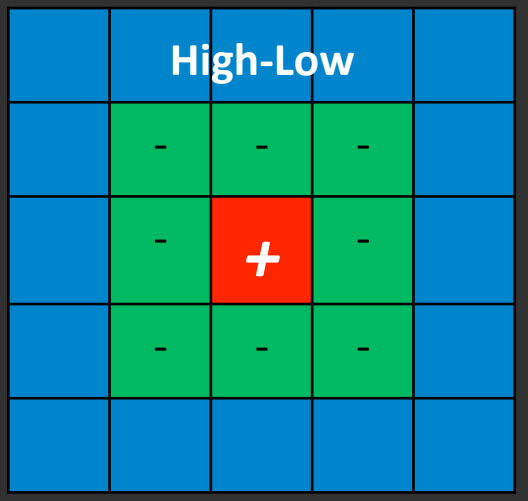
$$m_2 = \frac{\sum_i Z_i^2}{N}$$

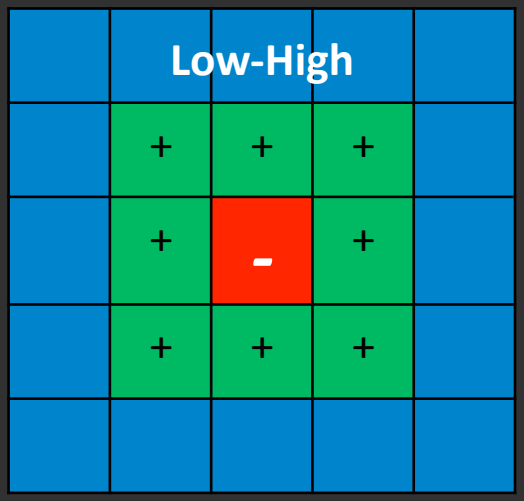
$W_{ij}$

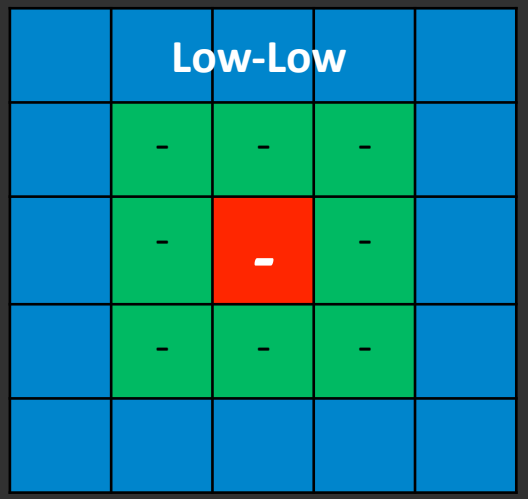
| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | ***i*** | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 |

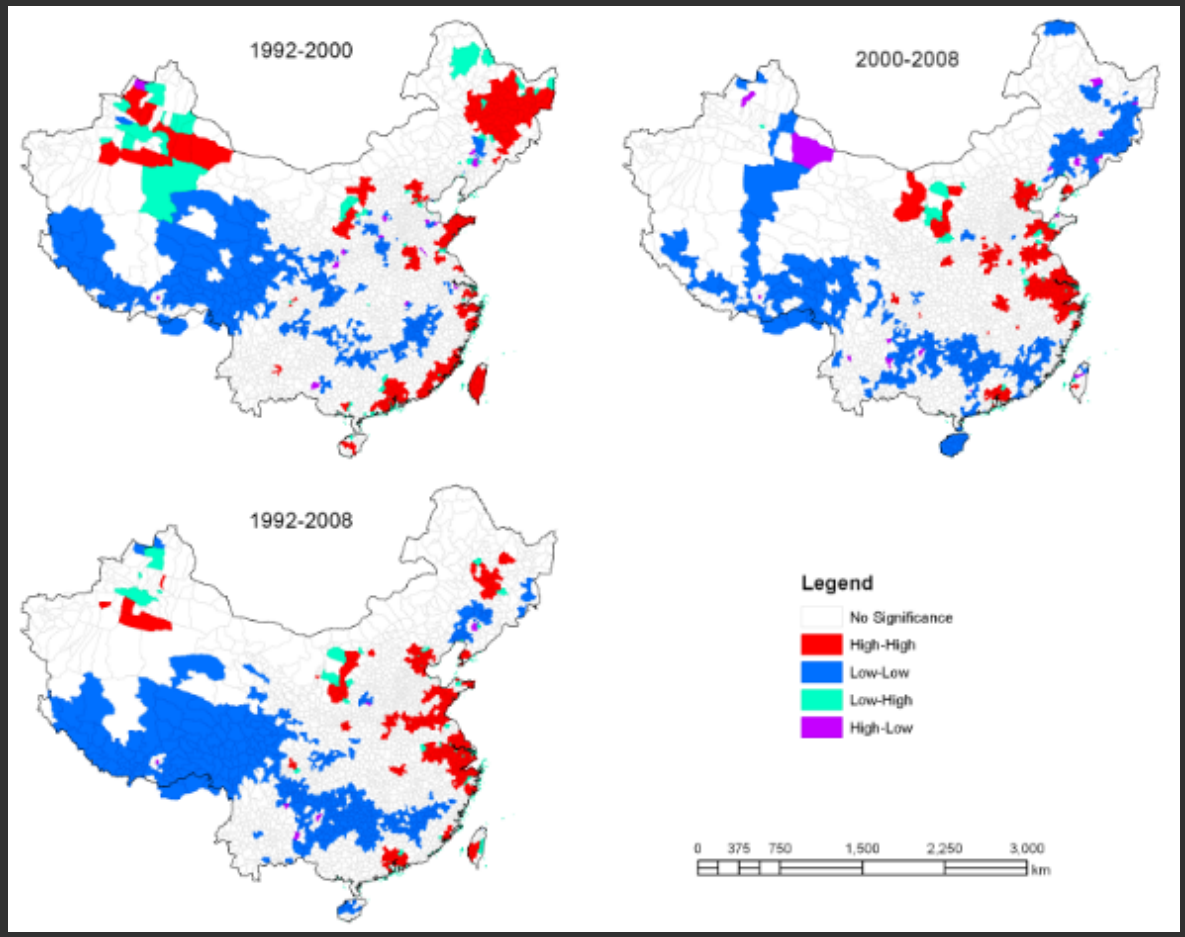
## Types of Clusters or Hotspot

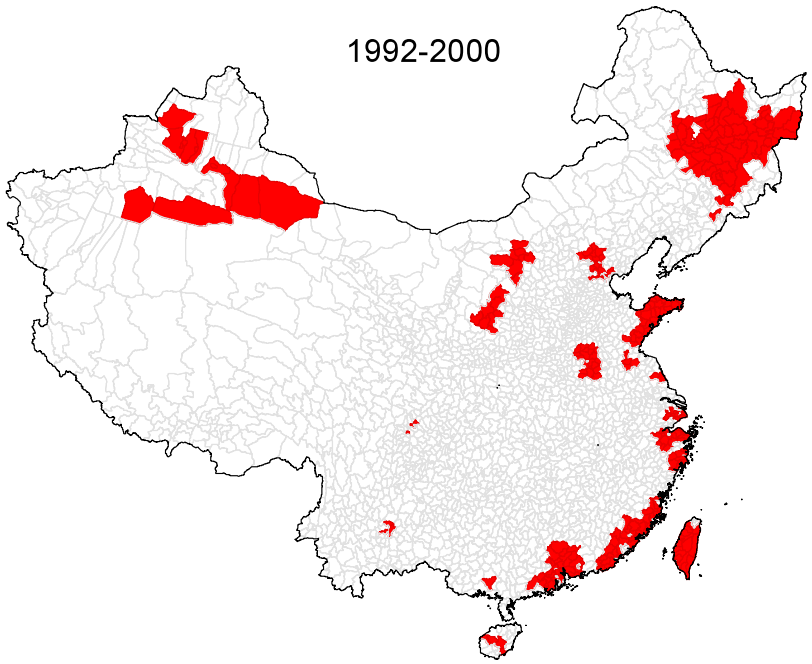


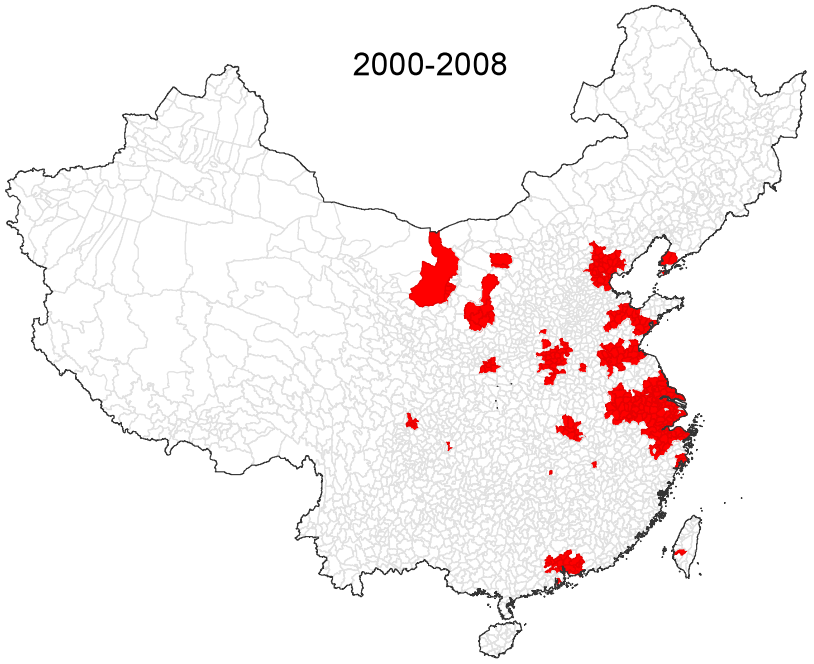



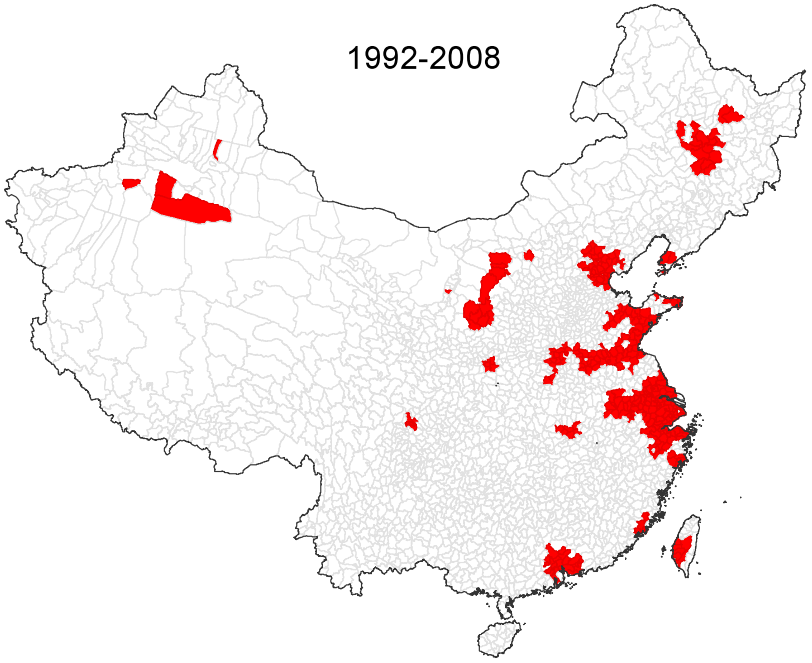




1992-2000
2000-2008
1992-2008
Legend
No Significance
High-High
Low-Low
Low-High
High-Low
0 375 750 1,500 2,250 3,000
km



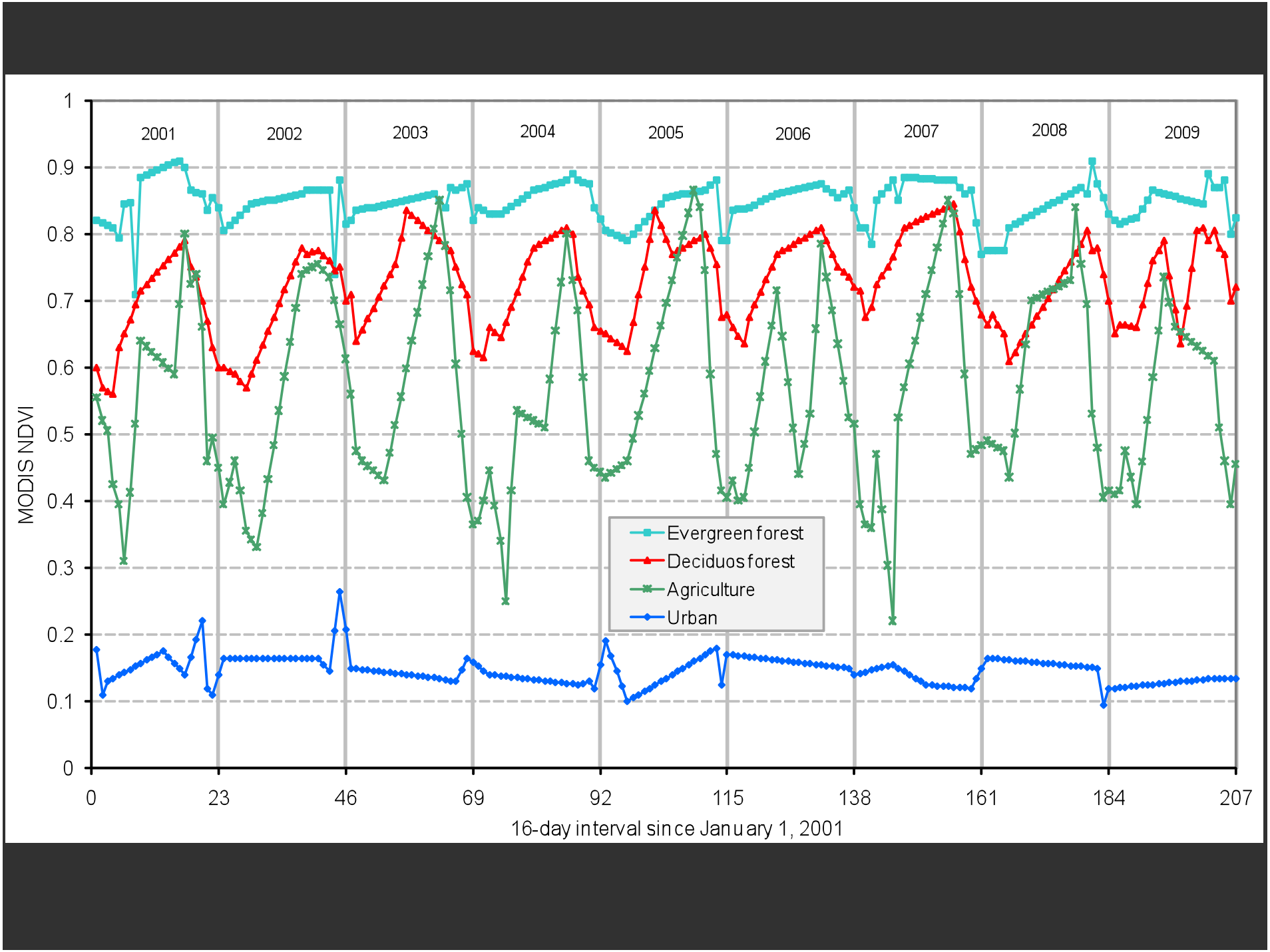



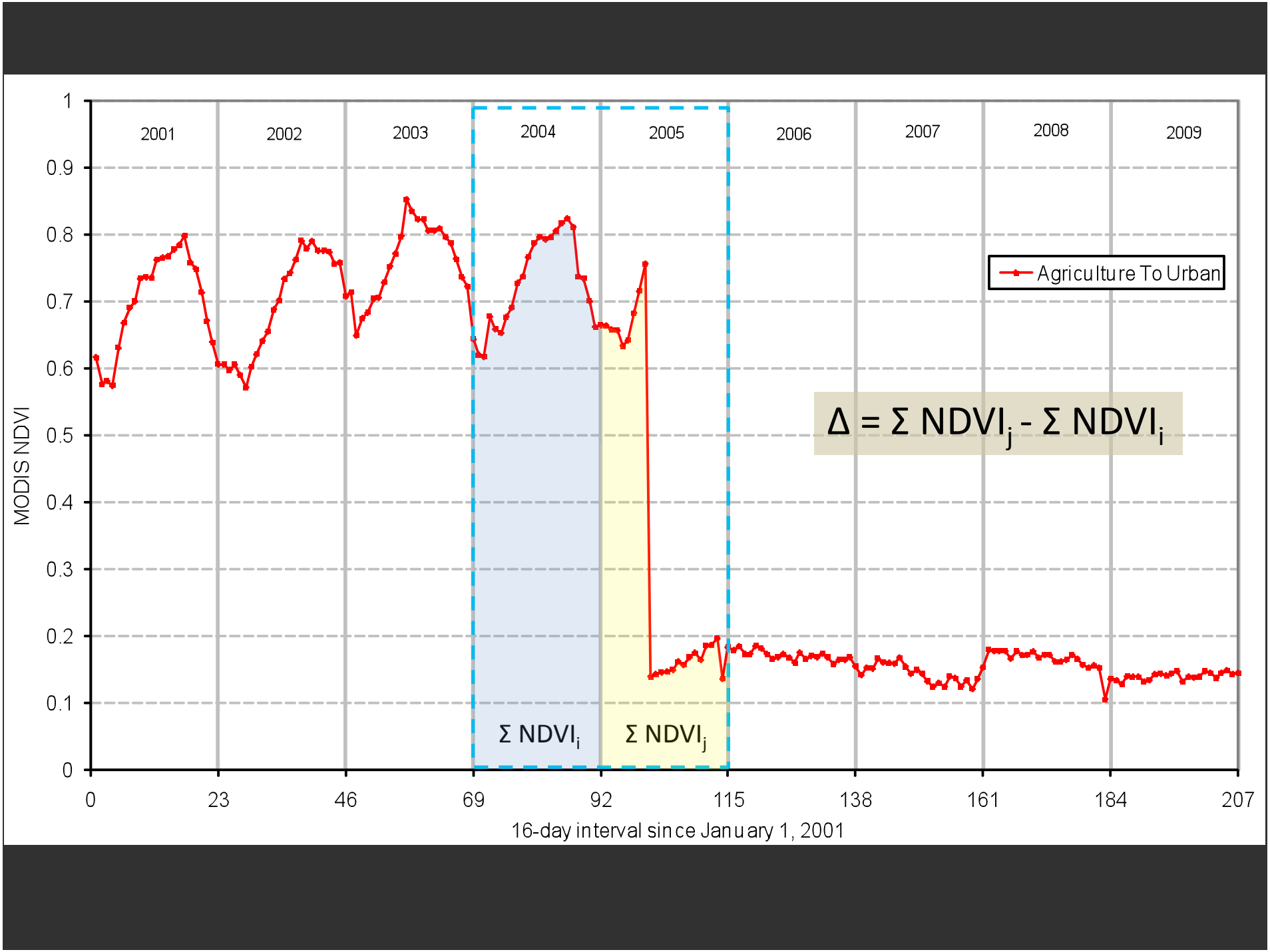

**Legend**

- China boundary
- County boundary
- Hot Spot

0 390 780 1,560 2,340 3,120

km


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
MODIS NDVI
2001
2002
2003
2004
2005
2006
2007
2008
2009
Evergreen forest
Deciduos forest
Agriculture
Urban
0
23
46
69
92
115
138
161
184
207
16-day interval since January 1, 2001


2001
2002
2003
2004
2005
2006
2007
2008
2009
Agriculture To Urban
Δ = Σ NDVIj - Σ NDVIi
Σ NDVIi
Σ NDVIj
MODIS NDVI
16-day interval since January 1, 2001
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
23
46
69
92
115
138
161
184
207

Questions?