Science Board Symposium (S1)

# Human footprints

# In the Northwestern Pacific Ocean

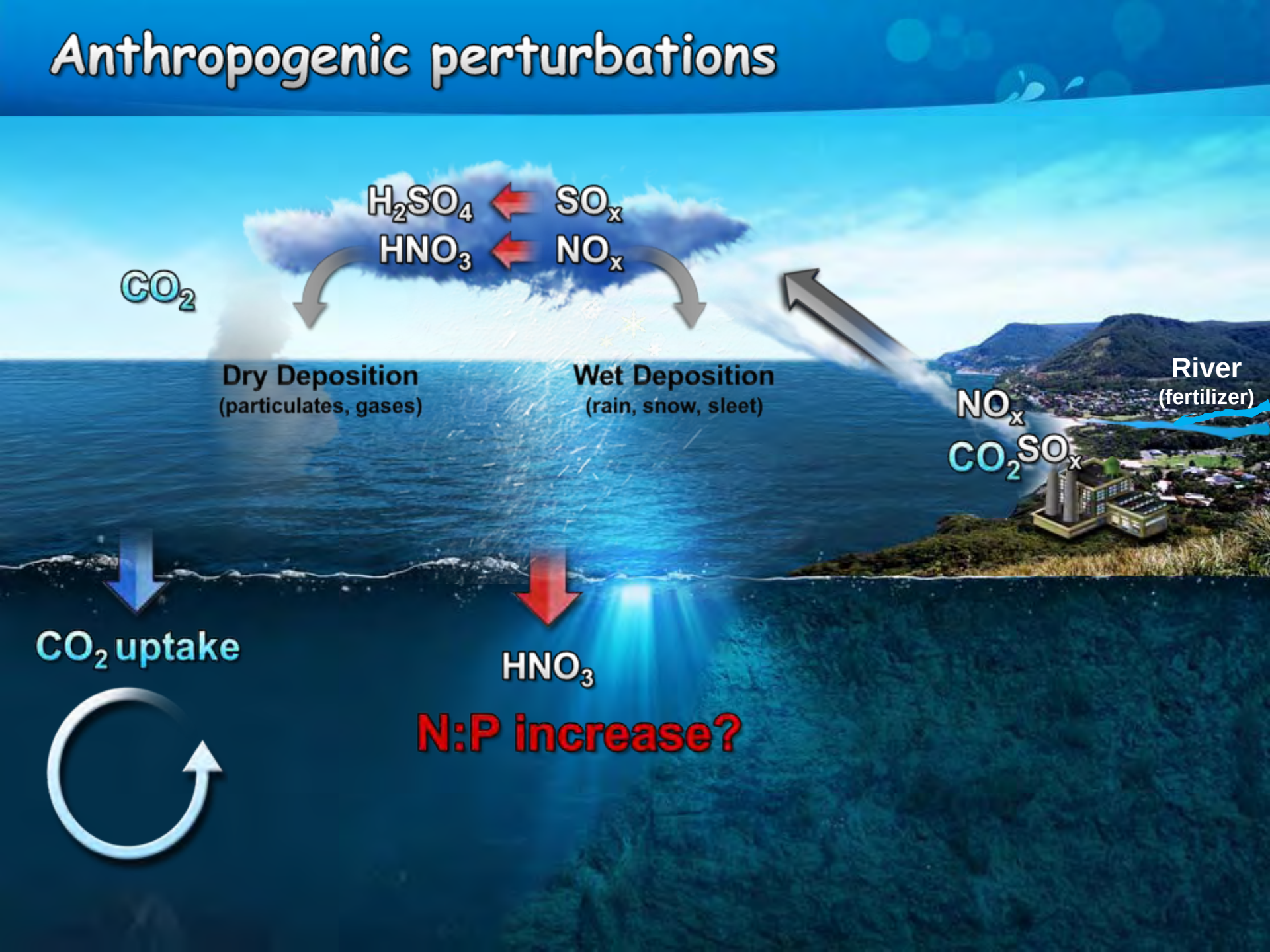
Kitack Lee

POSTECH

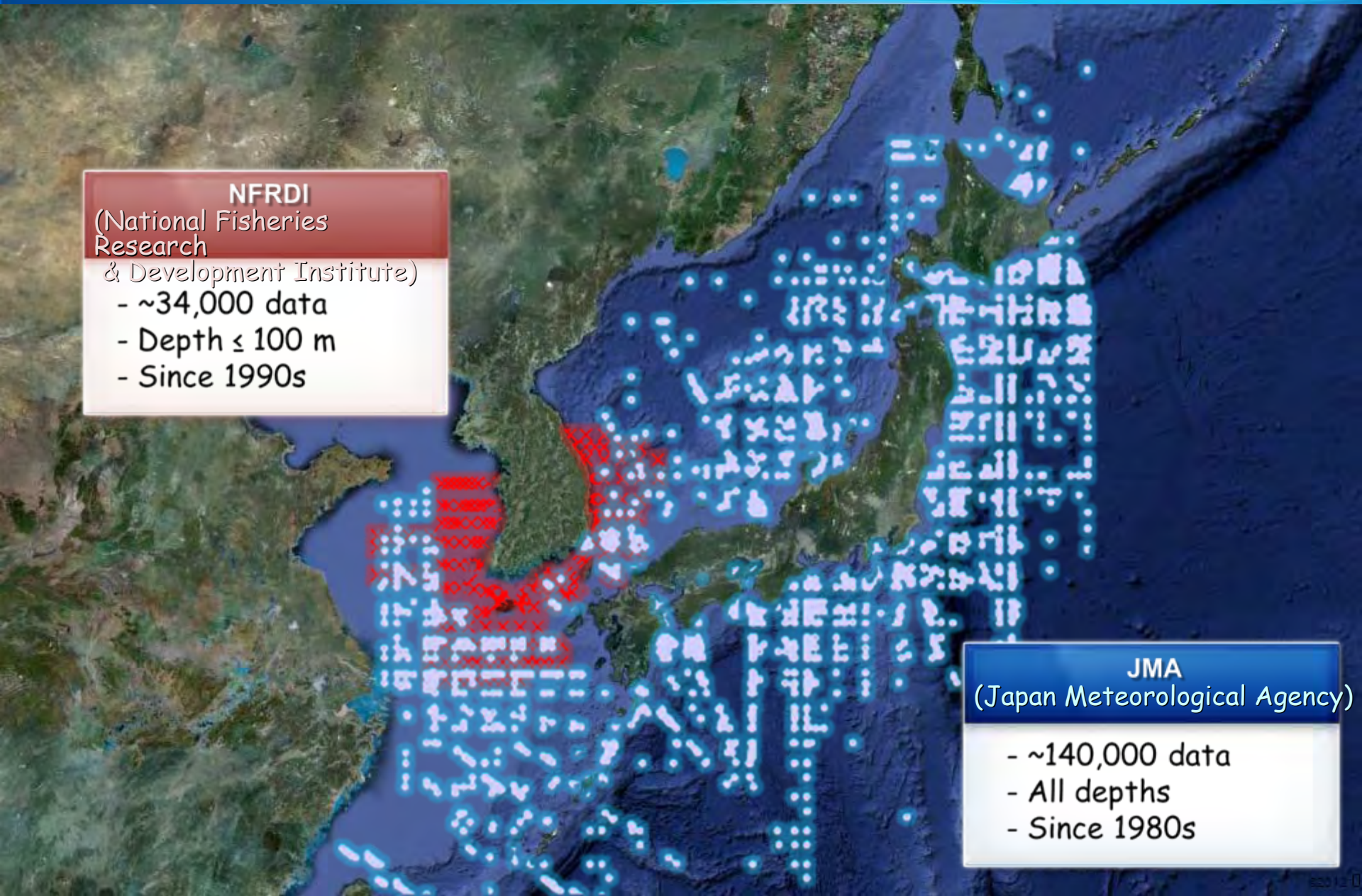
North Pacific Marine Science Organization

PICES-2012

October 12-21
Hiroshima, Japan


Anthropogenic perturbations
$H_2SO_4$
$SO_x$
$HNO_3$
$NO_x$
$CO_2$
Dry Deposition
(particulates, gases)
Wet Deposition
(rain, snow, sleet)
River
(fertilizer)
$NO_x$
$CO_2$ $SO_x$
$CO_2$ uptake
$HNO_3$
N:P increase?

# Ocean data (N, P)

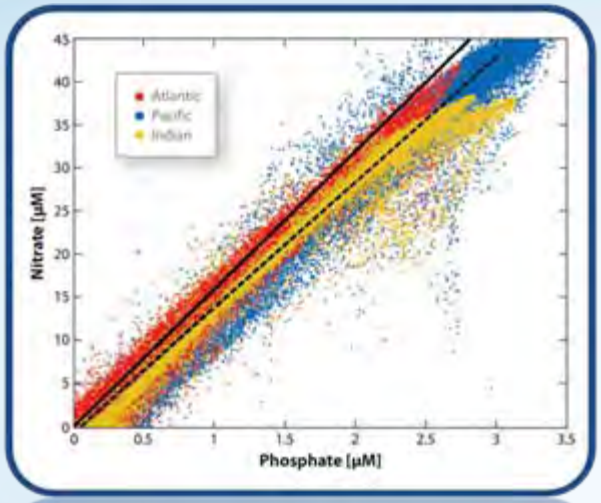


# Data treatment (at each sampling location)

$$N^* = N - (R_{N:P}) \times P$$ [Gruber and Sarmiento, GBC, 1997]

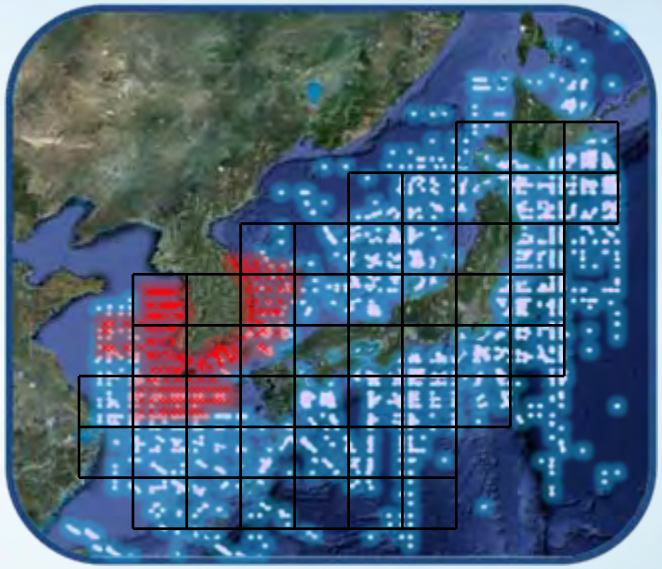
*where $R_{N:P}$ is N:P ratio of 16*

- $R_{N:P}$ Ratio of 16




[Deutsch et al., Annu. Rev. Mar. Sci, 2012]

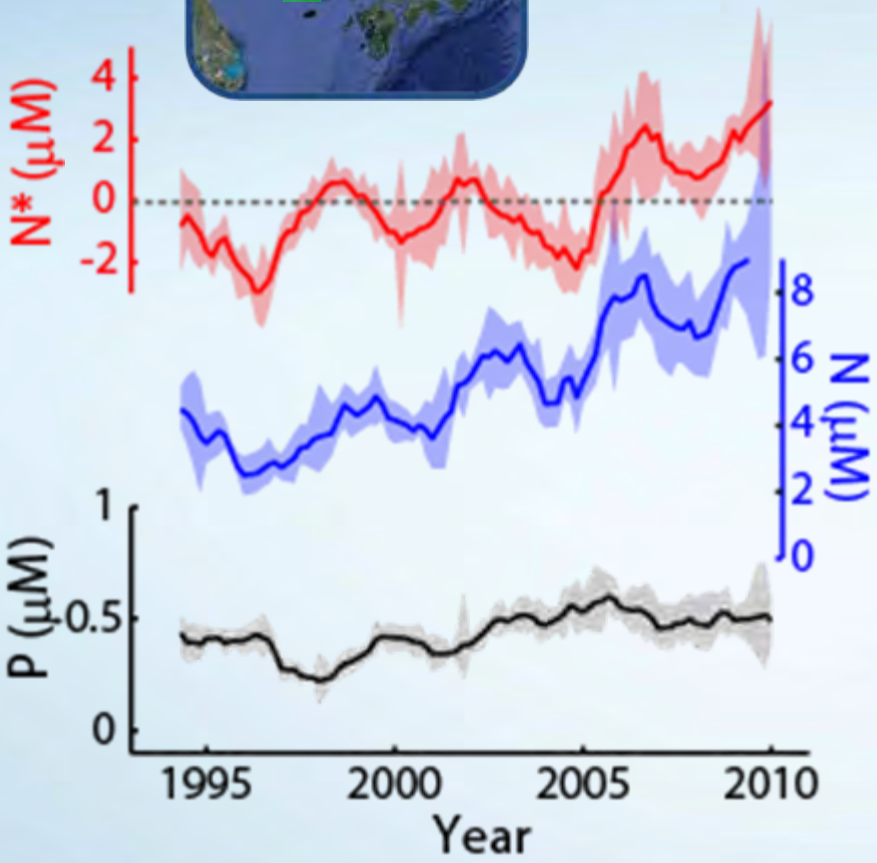
- Ocean box of 2° lat. × 2.5° long. (46 boxes)



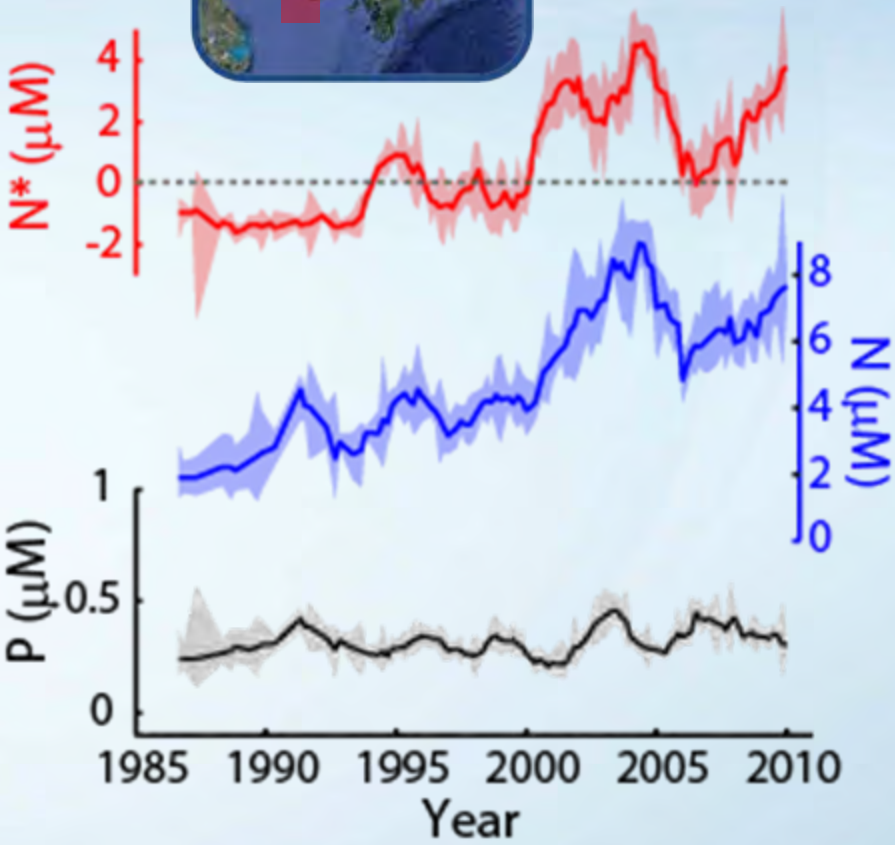
Raw Data (N, P, N*) → Bi-monthly Mean → 2-yr moving Mean

# Trends in N, P and N*

## Imsil



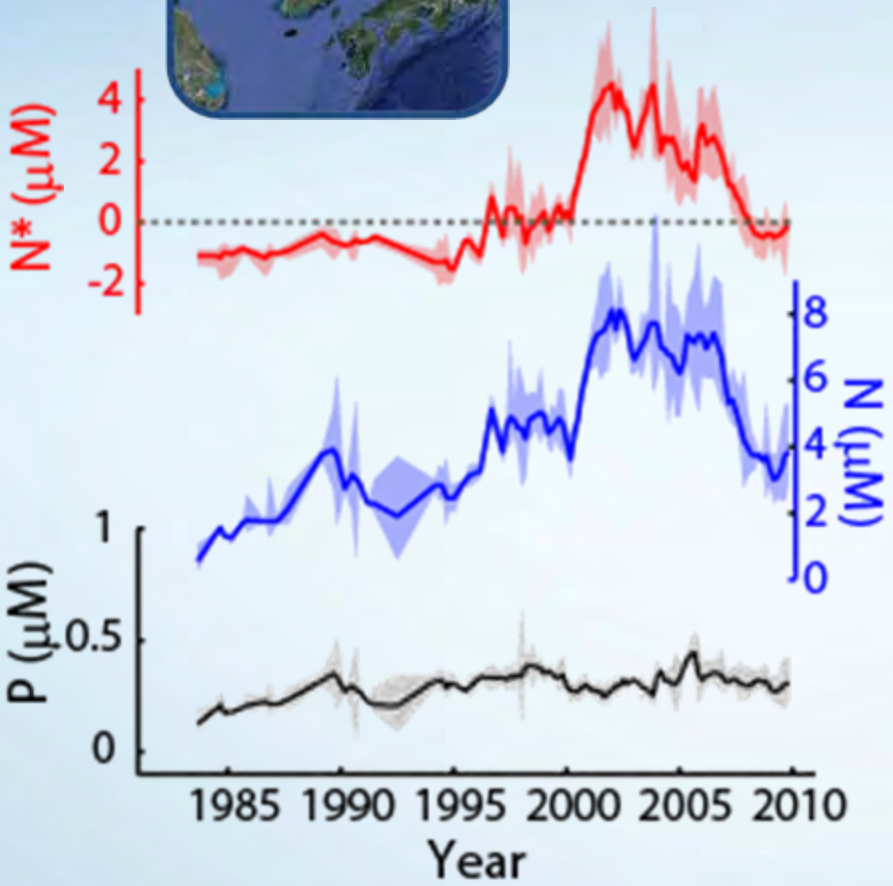

## Jeju Island



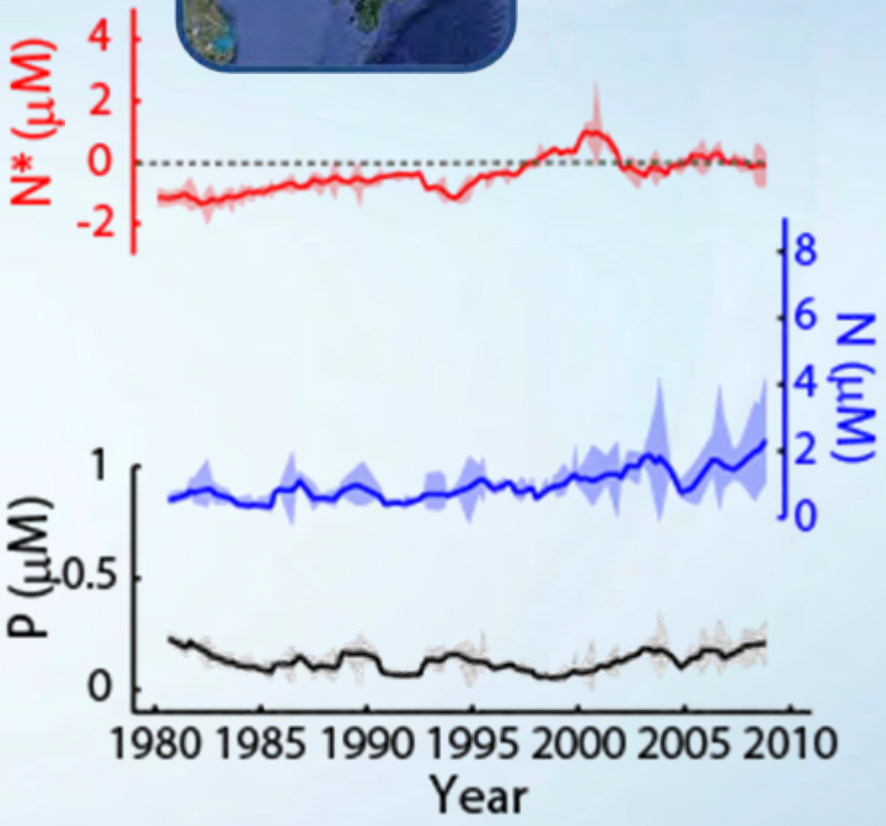

[Kim et al., Science, 2011]

# Trends in N, P and N*

## Uljin

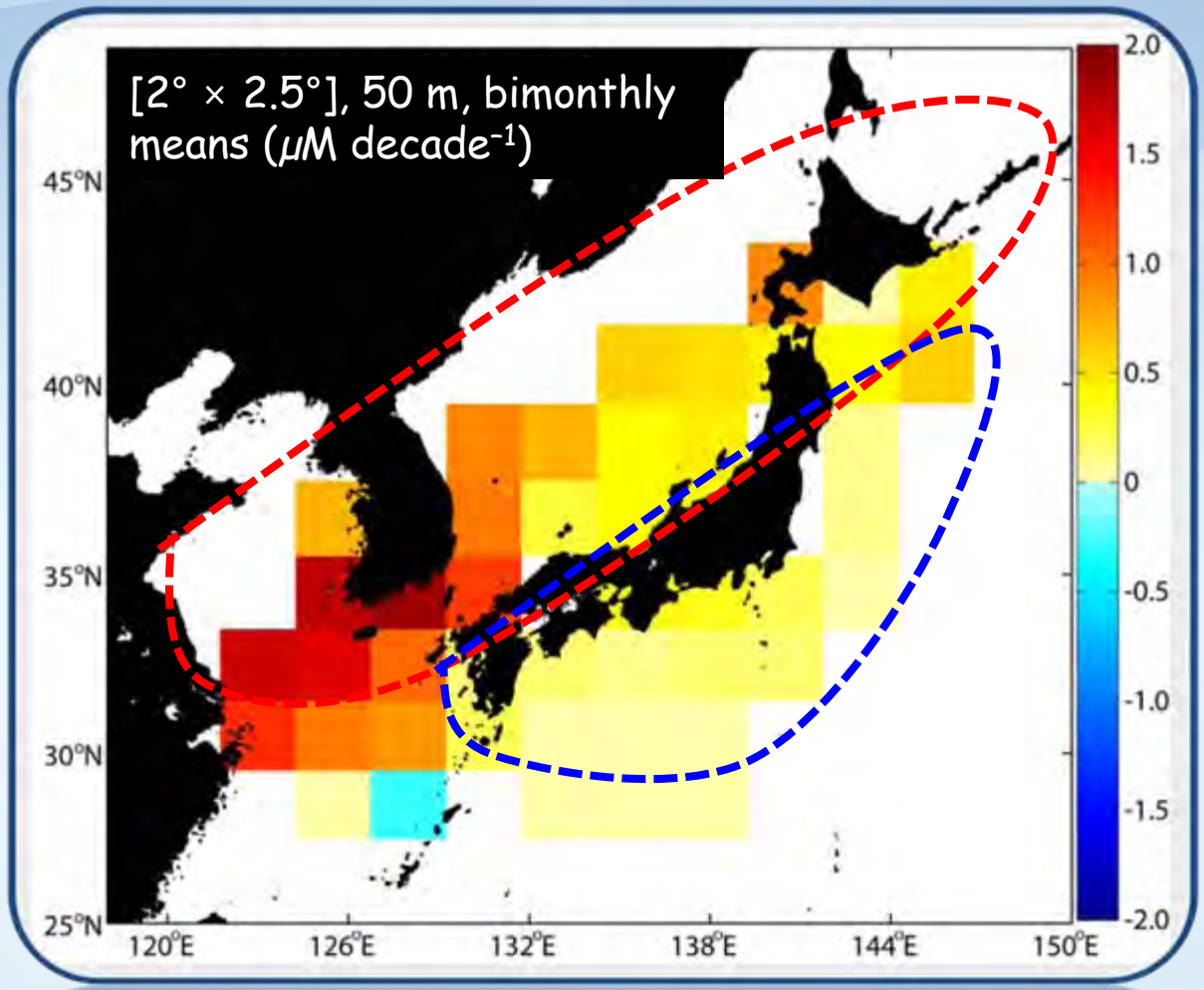



## Oki Island




[Kim et al., Science, 2011]

# Rates of surface N* change (<50 m)

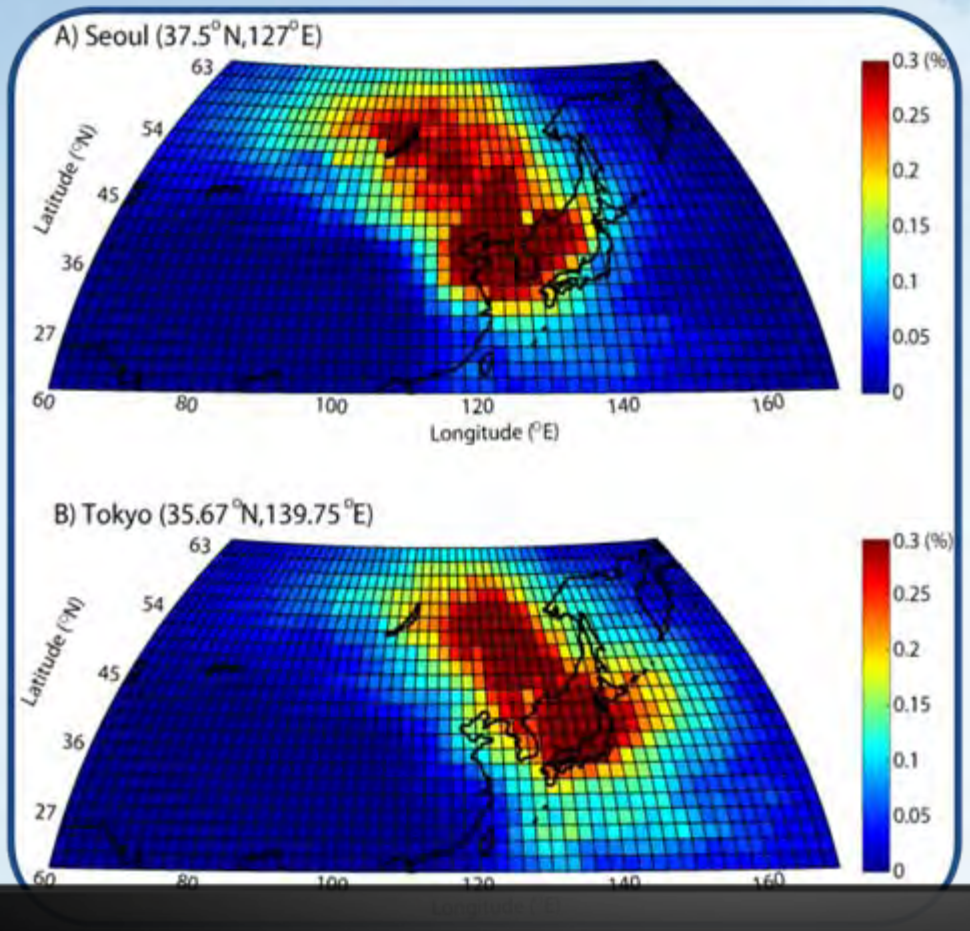



High and Significant  Low and Insignificant

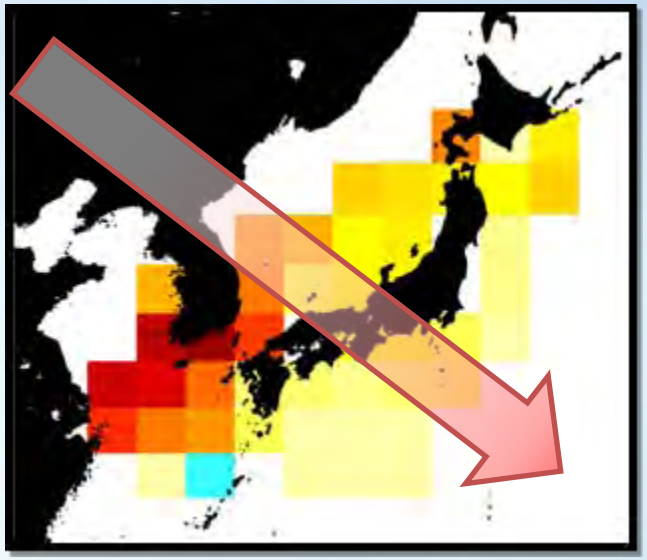
[Kim et al., Science, 2011]

# Air mass trajectory

- Dominant wind direction: northwest



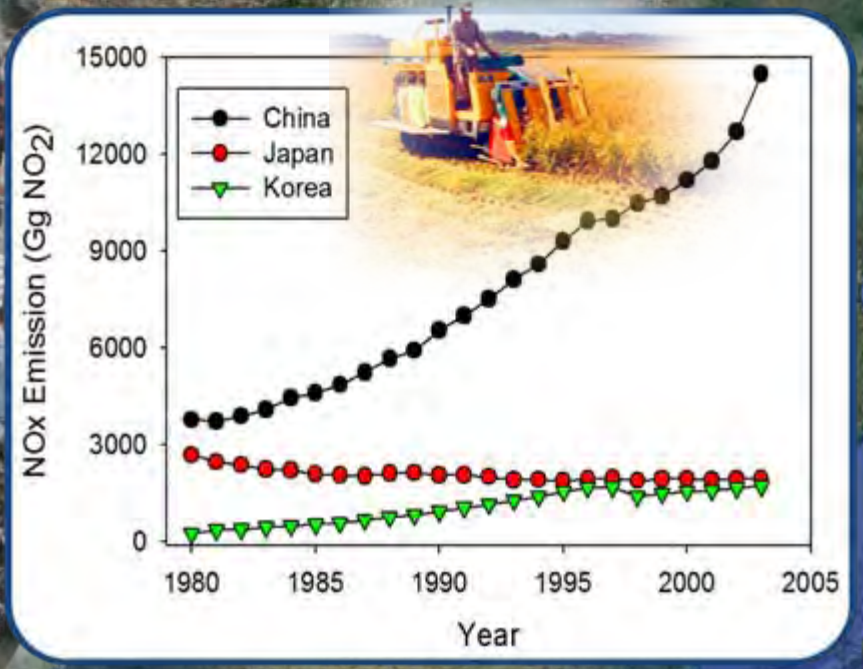

Wind direction
≈ Gradation of $\Delta N^*/\Delta t$

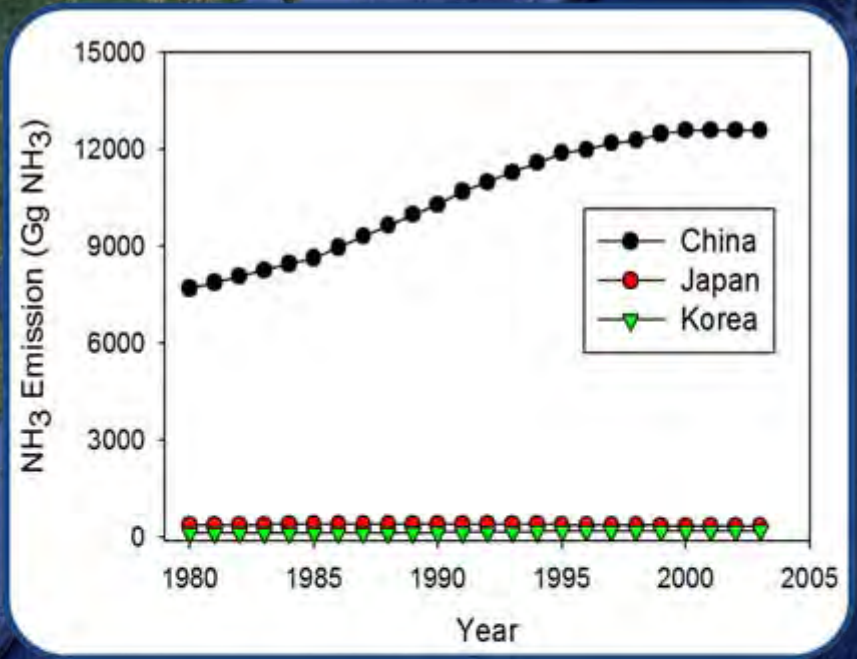


[Norwegian Institute for Air Research]
(NILU; at http://www.nilu.no/trajectories)

**Atmospheric N deposition may be responsible for N*↑**

# Atmospheric N Deposition?



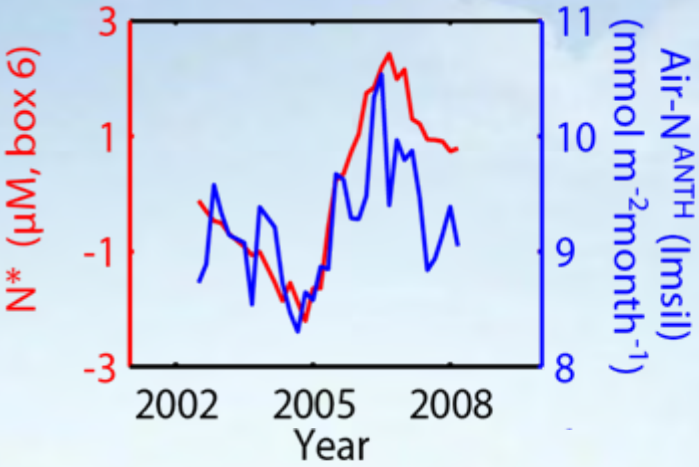



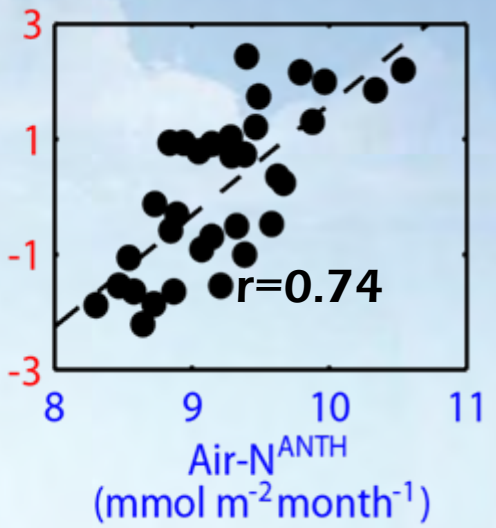

[Regional Emission Inventory in Asia]

Considerable N emissions from China, Japan, and Korea

# Air-N deposition vs. seawater N*

## Imsil

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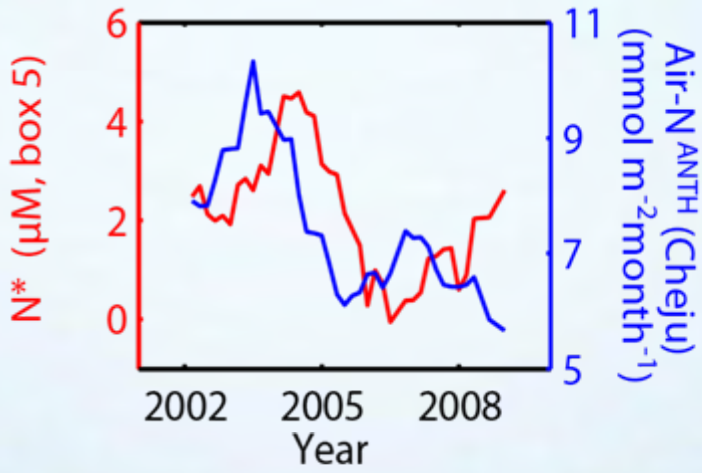
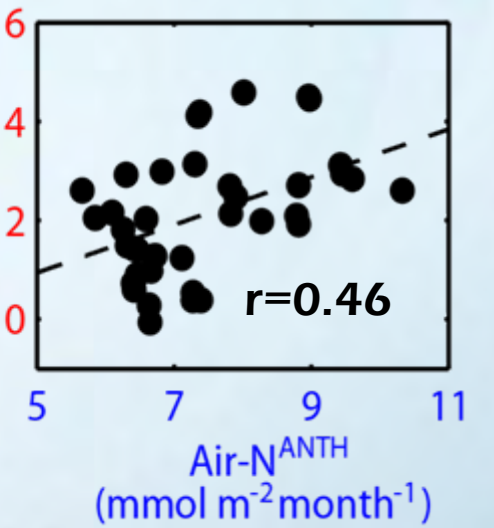
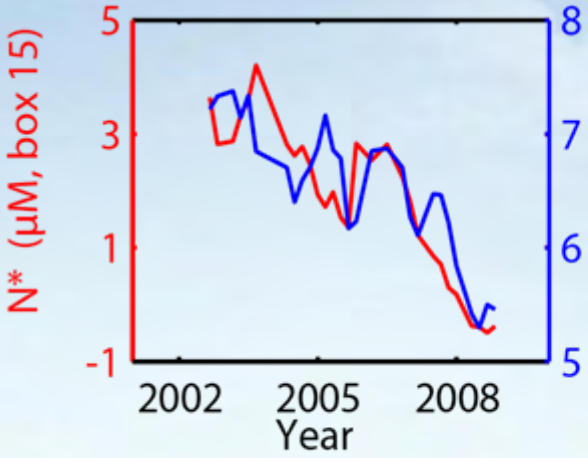


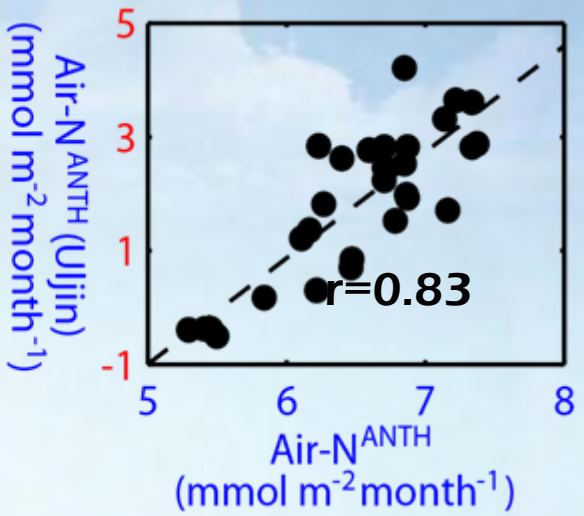




[Kim et al., Science, 2011]

# Air-N deposition vs. seawater N*

## Uljin

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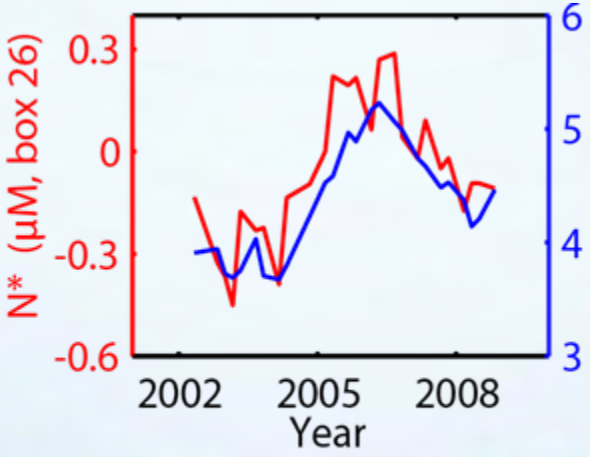
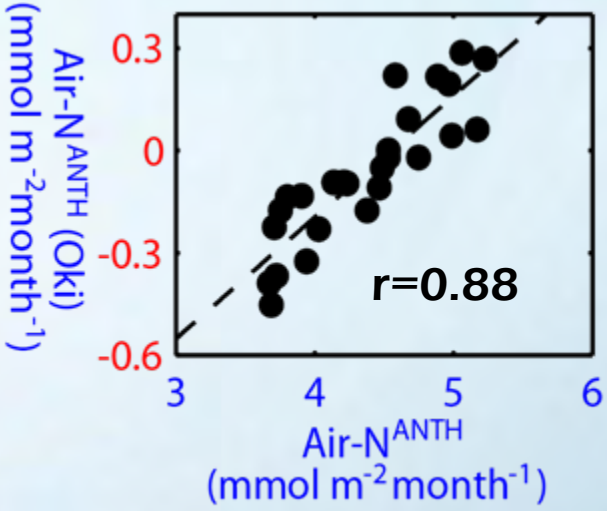
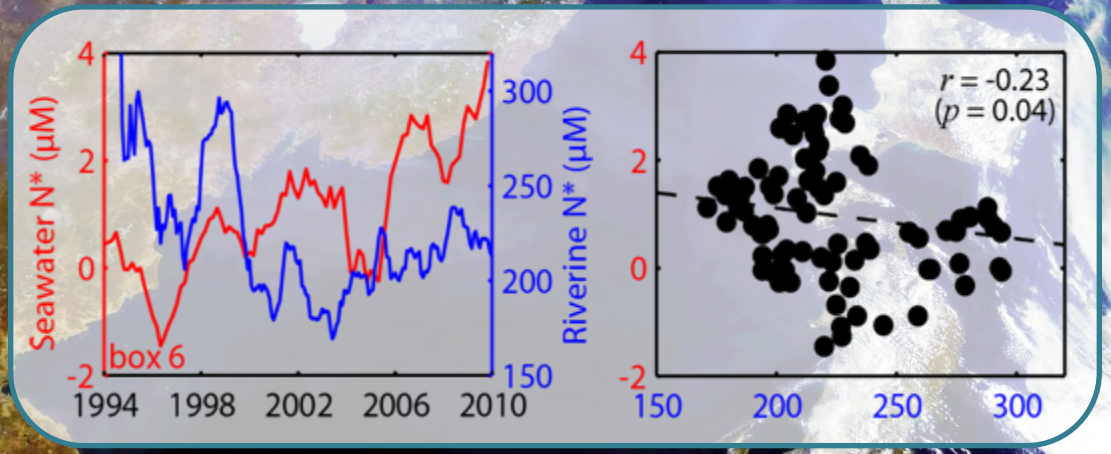


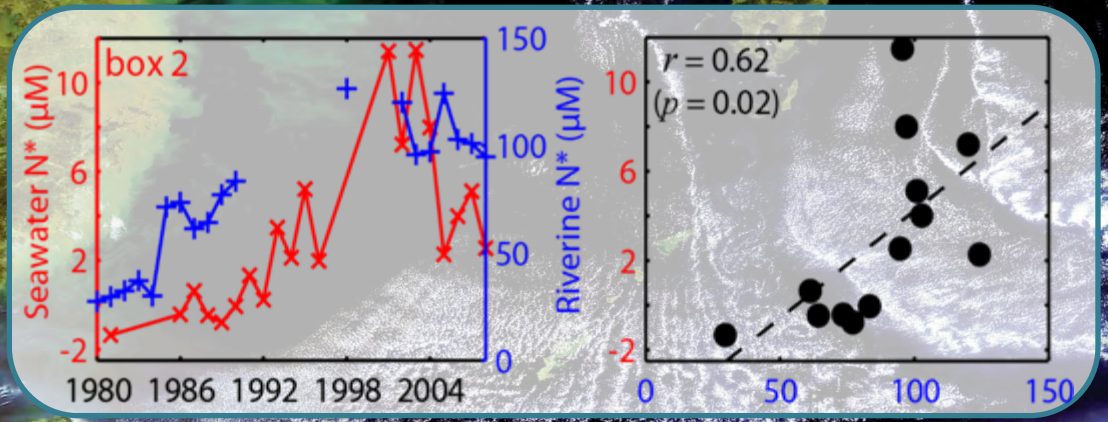

[Kim et al., Science, 2011]

# Other N sources: Rivers?

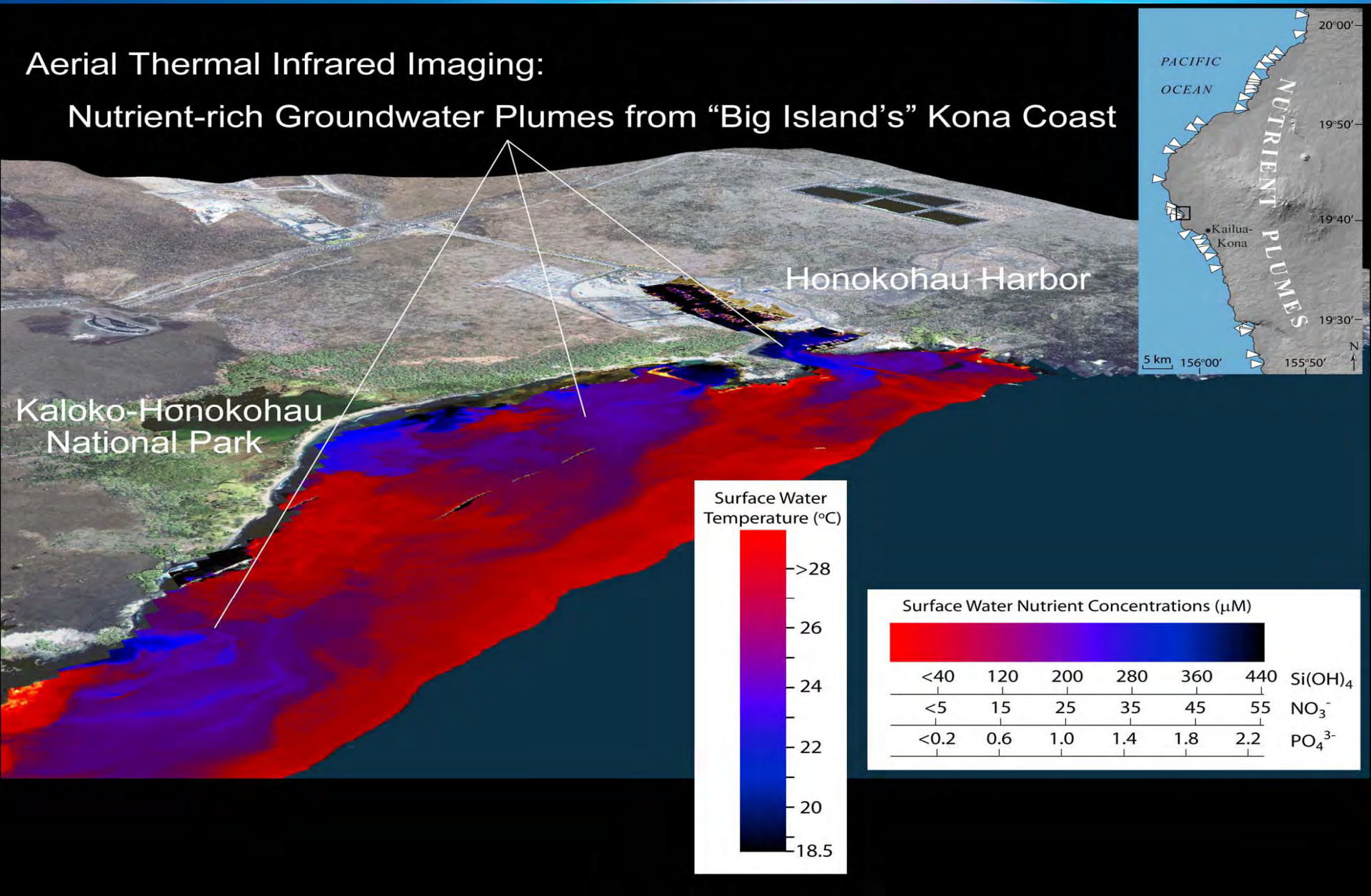



Han River

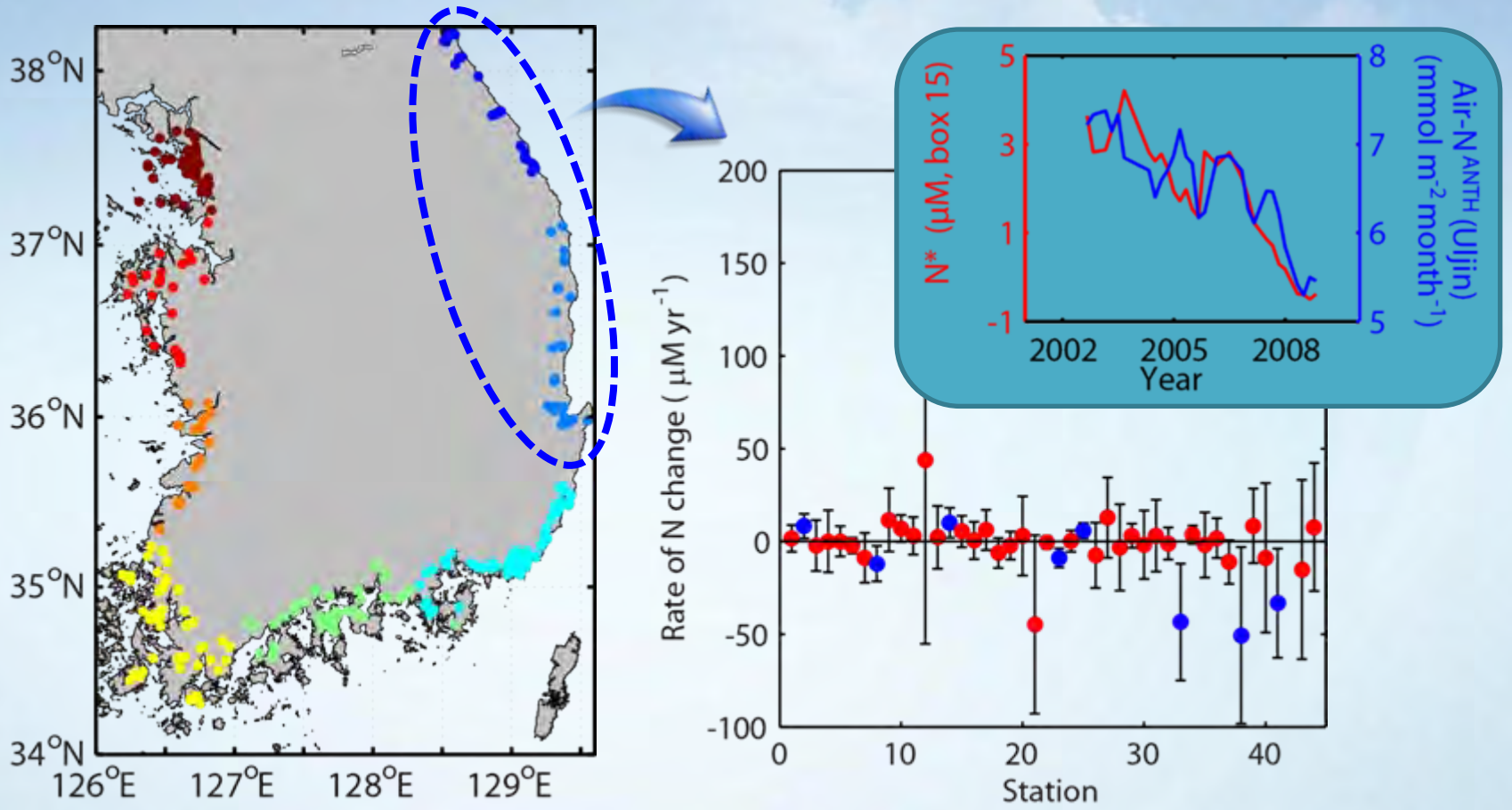
Changjiang River



# Other N sources: Groundwater?

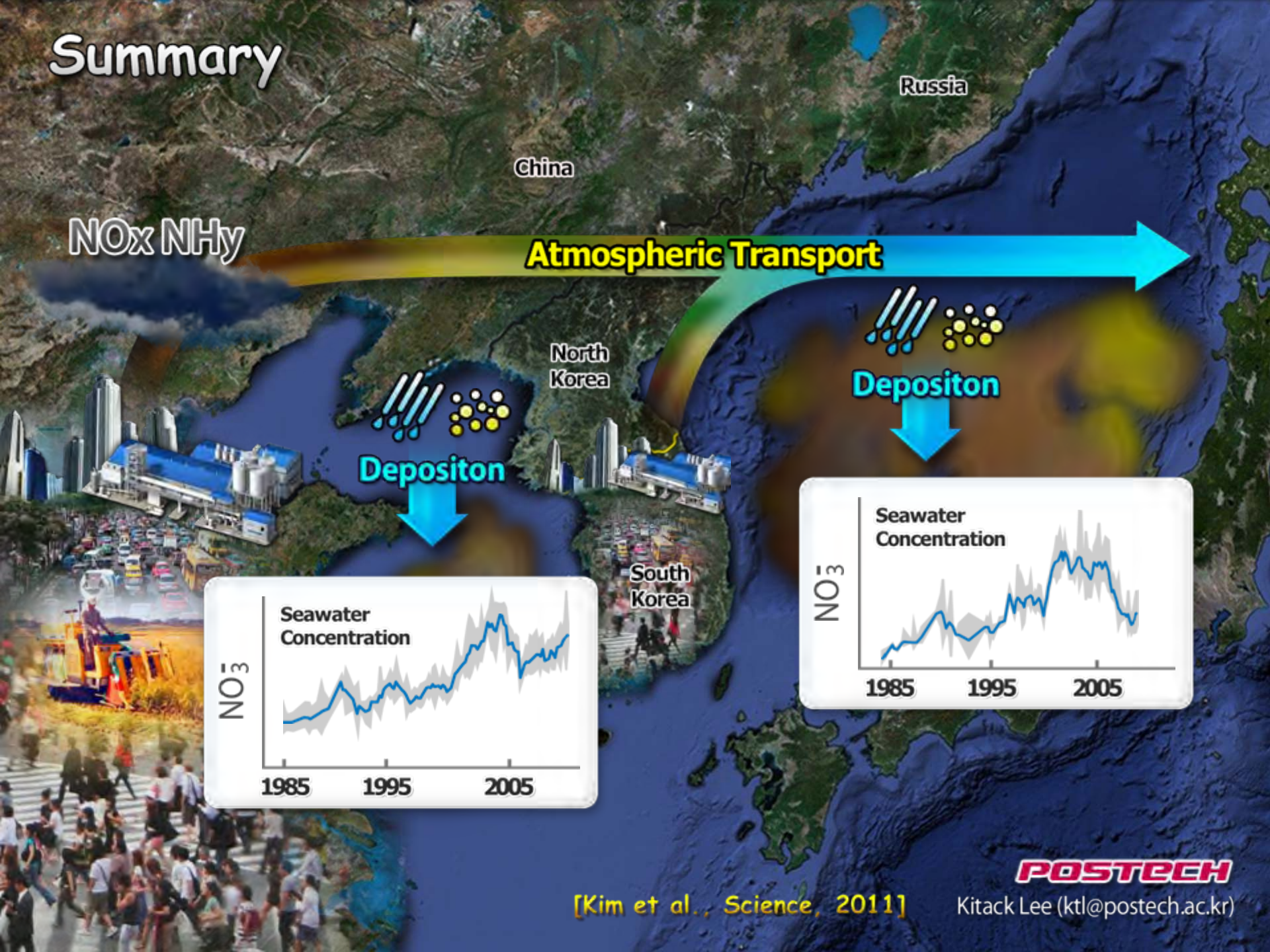


# Submarine groundwater discharge




[National Institute of Environmental Research]

# Summary




[Kim et al., Science, 2011]

POSTECH
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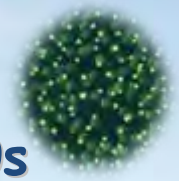
# Impact on marine ecosystem:

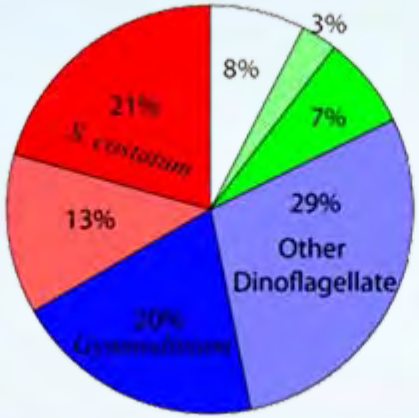
## N increase may switch a dominant species (maybe)



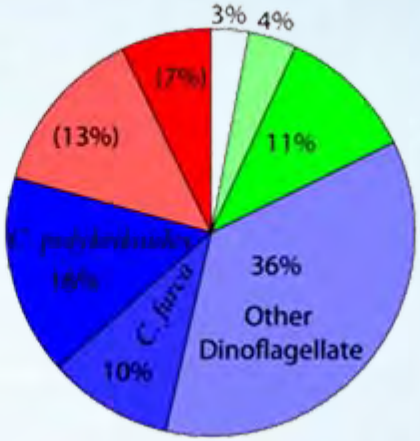
- *Skeletonema costatum*
- *Chaetoceros spp*
- Other Diatom
- *Heterosigma akashiwo*
- Other Rhaphidophyceae
- *Cochlodinium polykrikoides*
- *Gymnodinium* genus
- *Ceratium furca*
- Other Dinoflagellate
- etc

### 1970s

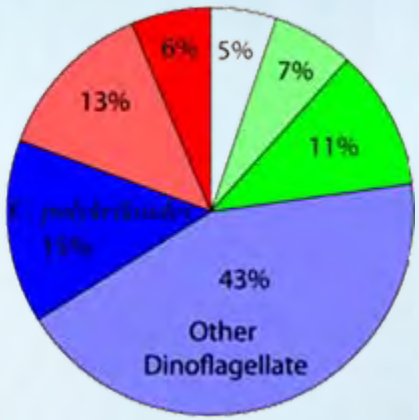

### 1980s




### 1990s




### 2000s




* KOSOMES: The Korean Society of Marine Environment and Safety (LIM ET AL., 2009)

## Diatom dominating ⇒ Dinoflagellate dominating