Application of Remote Sensing to Generate Historical Water Quality Data to Support Lake Management in Indonesia

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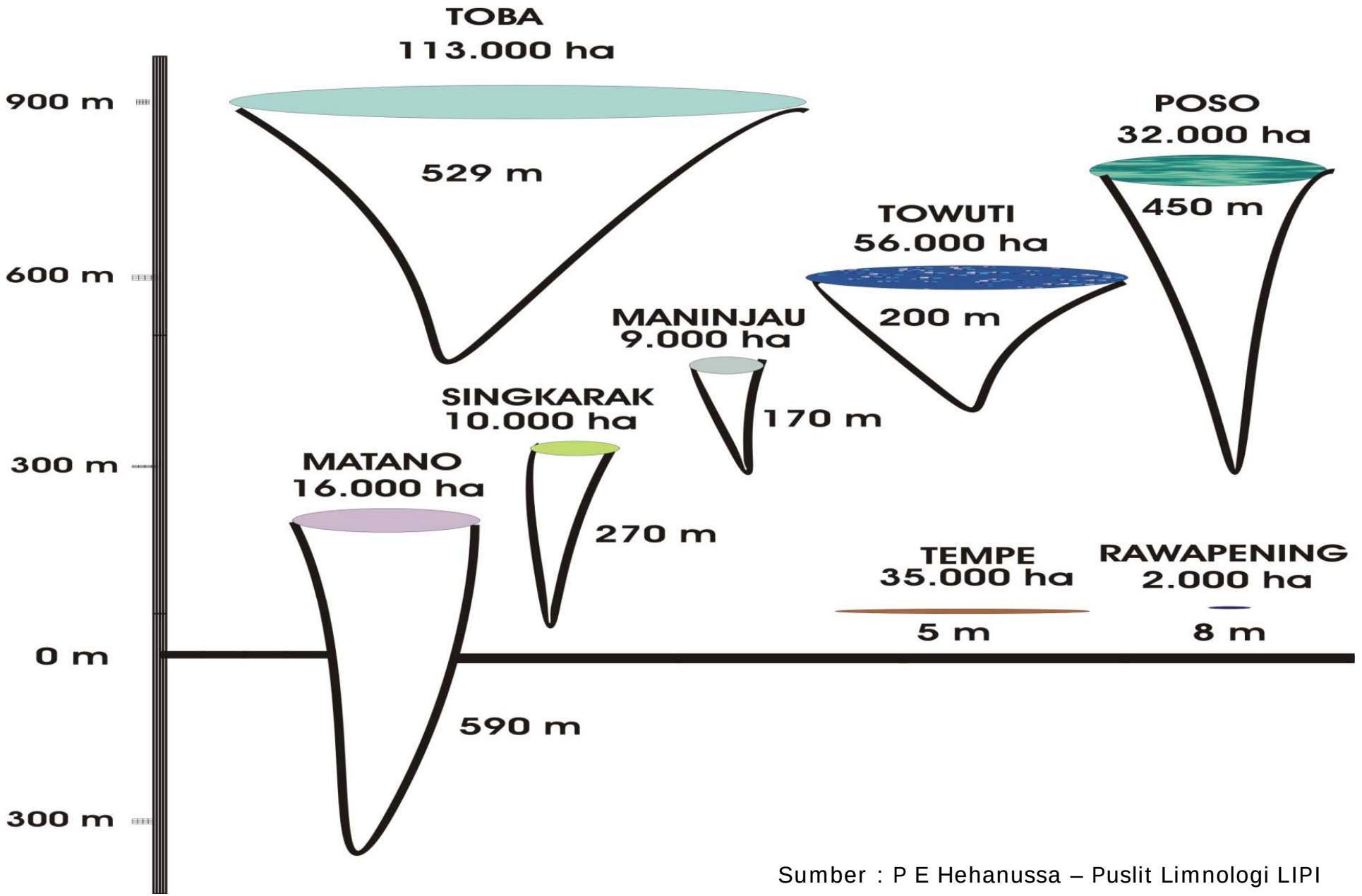
PROFILE OF LAKES IN INDONESIA



Sumber : P E Hehanussa – Puslit Limnologi LIPI

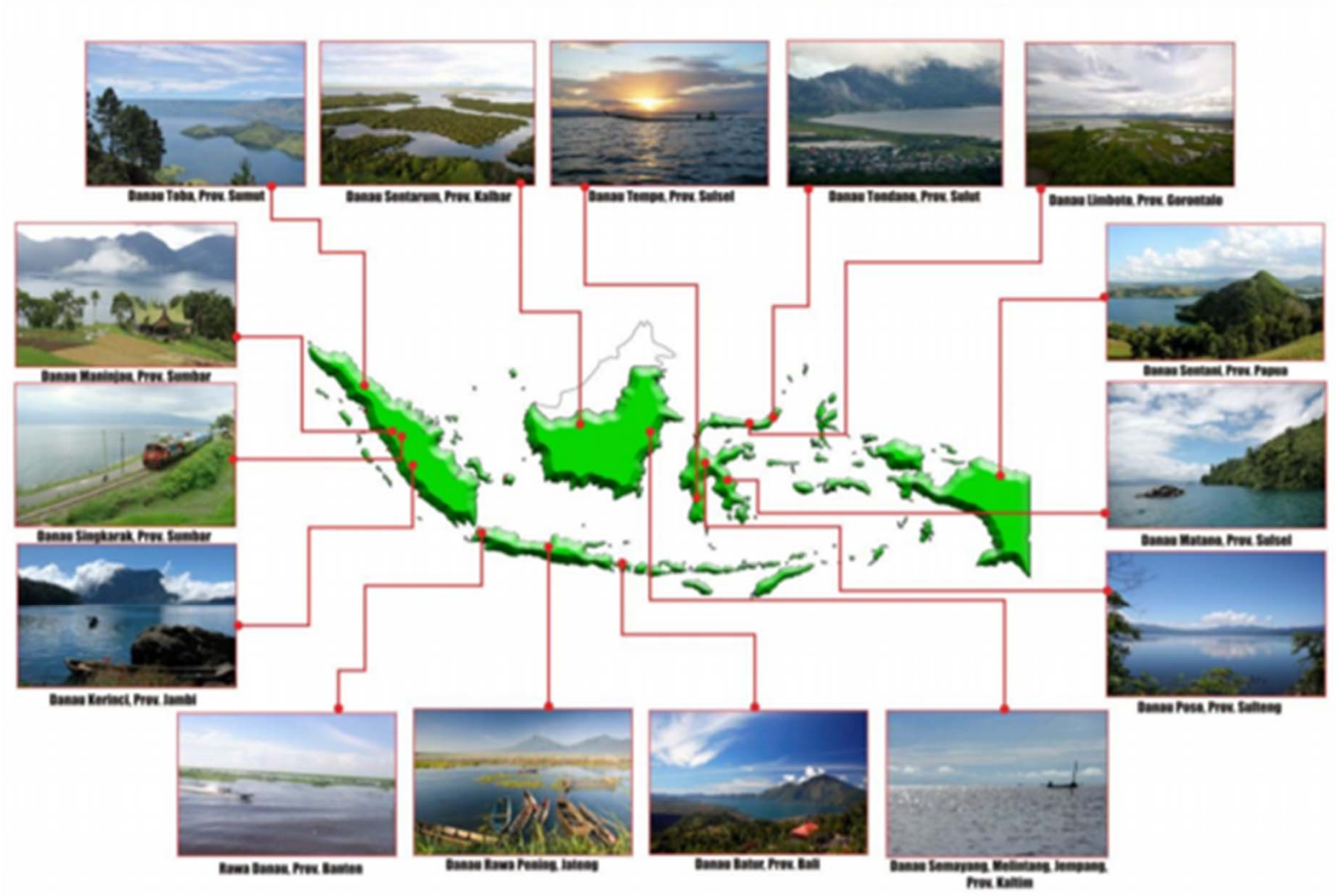
Lake Morphogenesis

No	Type/Lake Morphogenesis	Examples
1.	Tectonic lake	Lake Kerinci, Matano, Paniai
2.	Volcano-tektonik lake	Lake Toba, Maninjau, Tondano
3.	Caldera lake	Lake Batur, Bratan, Buyan
4.	Collapse/subsided lake	Lake Tolire
5.	Oxbow lake and floodplain	Lake Semayang, Melintang, Lake Teluk
6.	Faulted lake	Lake Singkarak, Ranau
7.	Dissolved lake	Lake Kei Kecil
8.	Estuarine lake	Lake Aiduna, Segara Anakan
9.	Artificial lake/reservoir, embung, situ, tasik	Saguling, Jatiluhur, Rawa Pening reservoirs
10.	Abandoned mining pit	Kolong di Bangka

Source : G.S. Haryani, 2013

Assessment criteria of the designated the Indonesian priority lakes are as follow:

1. **Lake damage; level of sedimentation, pollution, eutrophication, highly reduced quality and quantity of water.**
2. Lake utilization; hydropower plant, agriculture, fisheries (aquaculture/floating cage), usable water, religious and culture values, tourism (including lake uniqueness, accessibility, amenity-infrastructure and society condition).
3. Local government's and society's commitment to wisely manage lakes (master plan, local regulation (perda), managing committee).
4. Strategic lake; lakes featuring strategic functions of national interest.
5. Biodiversity (including endemic fish species, aves and vegetation).
6. Carbon urgency (the challenge against global climate change).



Distribution map of 15 National Priority Lakes
(Indonesian Ministry of Environment. 2011)

The 15 priority lakes (2010 – 2014) :

Lake Toba (North Sumatera),
Lake Maninjau and Lake Singkarak (West Sumatera),
Lake Kerinci (Jambi),
Lake Rawa Danau (Banten),
Lake Rawapening (Central Java),
Lake Batur (Bali),
Lake Tempe and Lake Matano (South Sulawesi),
Lake Poso (Central Sulawesi),
Lake Tondano (North Sulawesi),
Lake Limboto (Gorontalo),
Lake Sentarum (West Kalimantan),
Cascade Mahakam Lake – Lake Semayang, Lake Melintang,
Lake Jempang (East Kalimantan) and
Lake Sentani (Papua).

The 15 priority lakes (2015 – 2019) :

Lake Diatas, Lake Dibawah (West Sumatera),
Lake Ranau (South Sumatera),
Lake Dendam Tak Sudah (Bengkulu),
Lake Lindu (Centre of Sulawesi),
Lake Towuti, Lake Mahalona (South of Sulawesi),
Lake Bratan (Bali),
Lake Paniai (Papua),
Lake Laut Tawar, Lake Aneuk Laot (Aceh),
Lake Kelimutu (Nusa Tenggara Timur),
Lake Rinjani, Lake Taliwang (Nusa Tenggara Barat) and
Lake Tasik Zamrud (Riau).

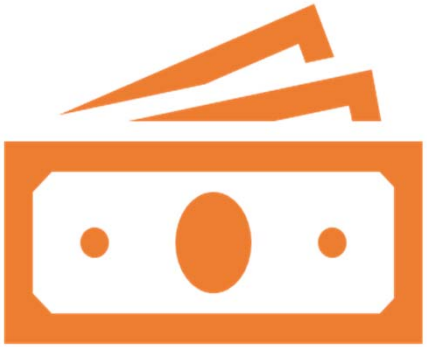
Indonesian lakes

Mostly situated in remote area

Multiple used:
domestic life, industry, agriculture, transportation, energy, fisheries, and tourism

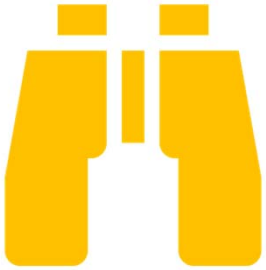
problems:
eutrophication,
sedimentation,
DO depletion

Data scarcity



financial constraints

Geographic constraint



View institution observing lakes

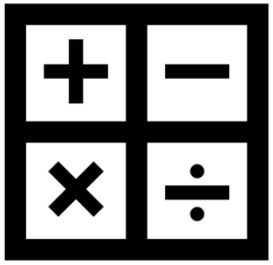
Remote sensing data for lake

powerful tool for a routine water quality data collecting

provide opportunities to build water quality database for Indonesian lakes and reservoirs.

Water quality estimation from remote sensing

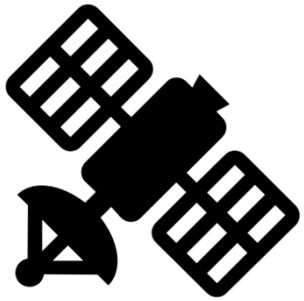
Requires:



Good quality of satellite data

Robust models for both clear and turbid water

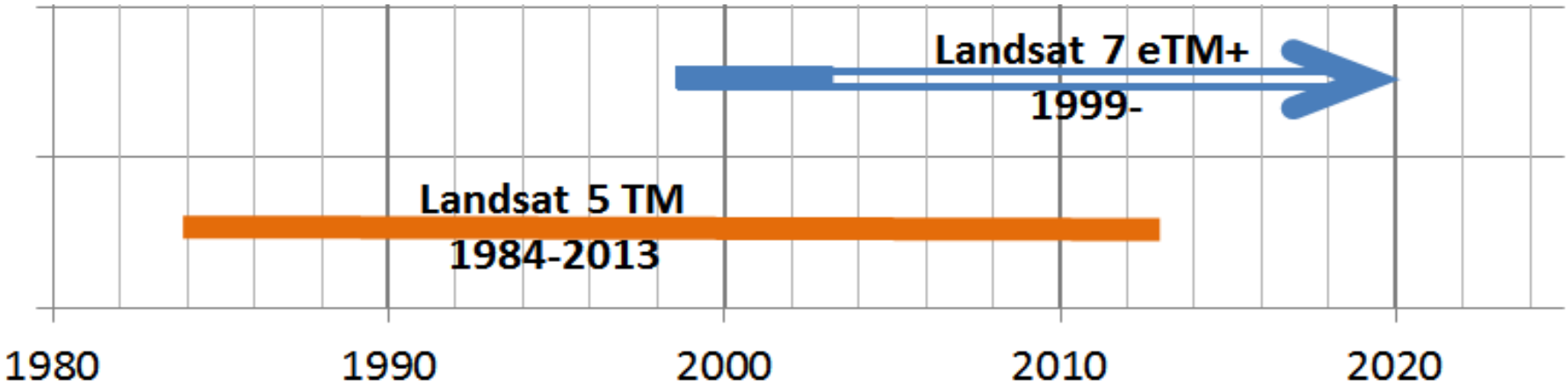
Which satellite data and what water quality parameter?



Landsat TM and ETM+

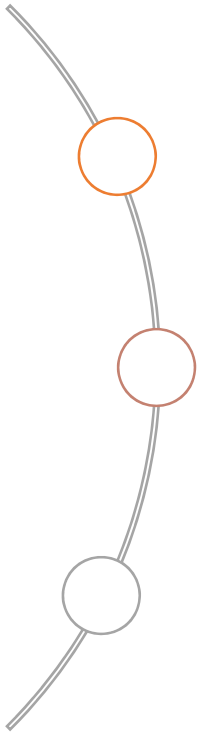
Secchi disk depth (SD)

Why Landsat ?



- **longest** satellite missions observing the earth
- Record every 16 days from 1987 –now
- High spatial resolution (30 m)
- Free data sources
- enabling extraction of historical water quality

Why Secchi Disk Depth ?



Easy to measure

Values can be directly obtained

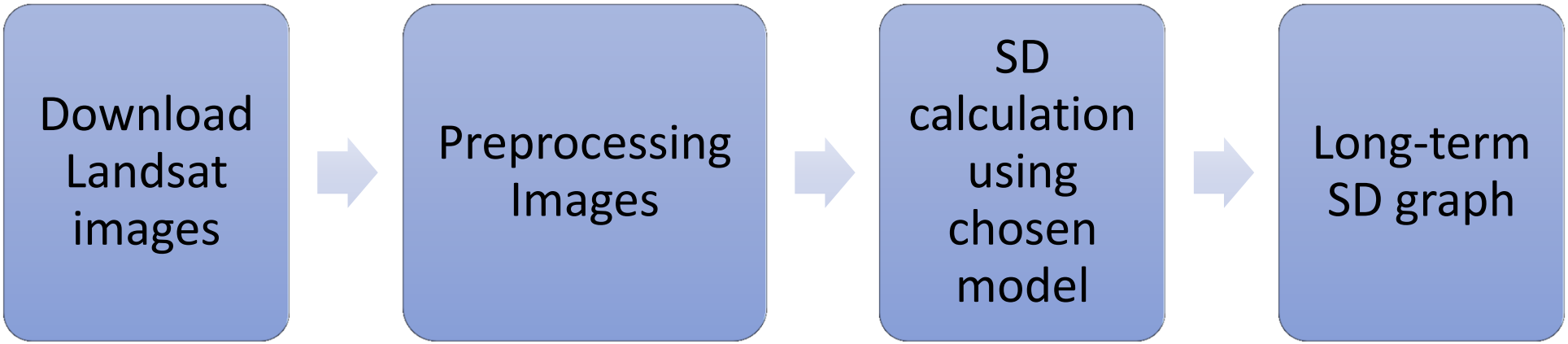
Easy to interpret

Which Secchi Disk Depth Model?

empirical models, have been widely used to estimate the SD in inland waters

Which model ???

How to estimate SD from the chosen satellite and model ?

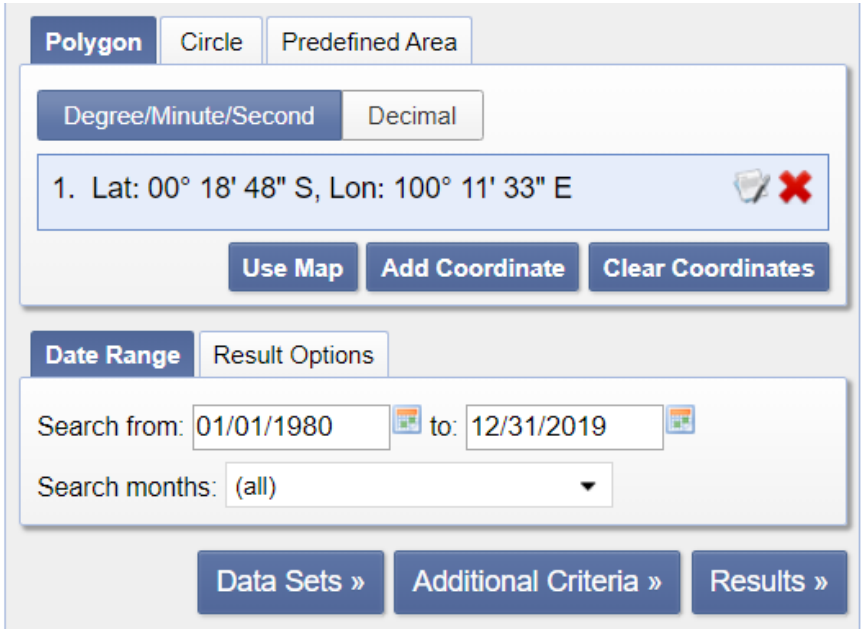


How to download Landsat Data

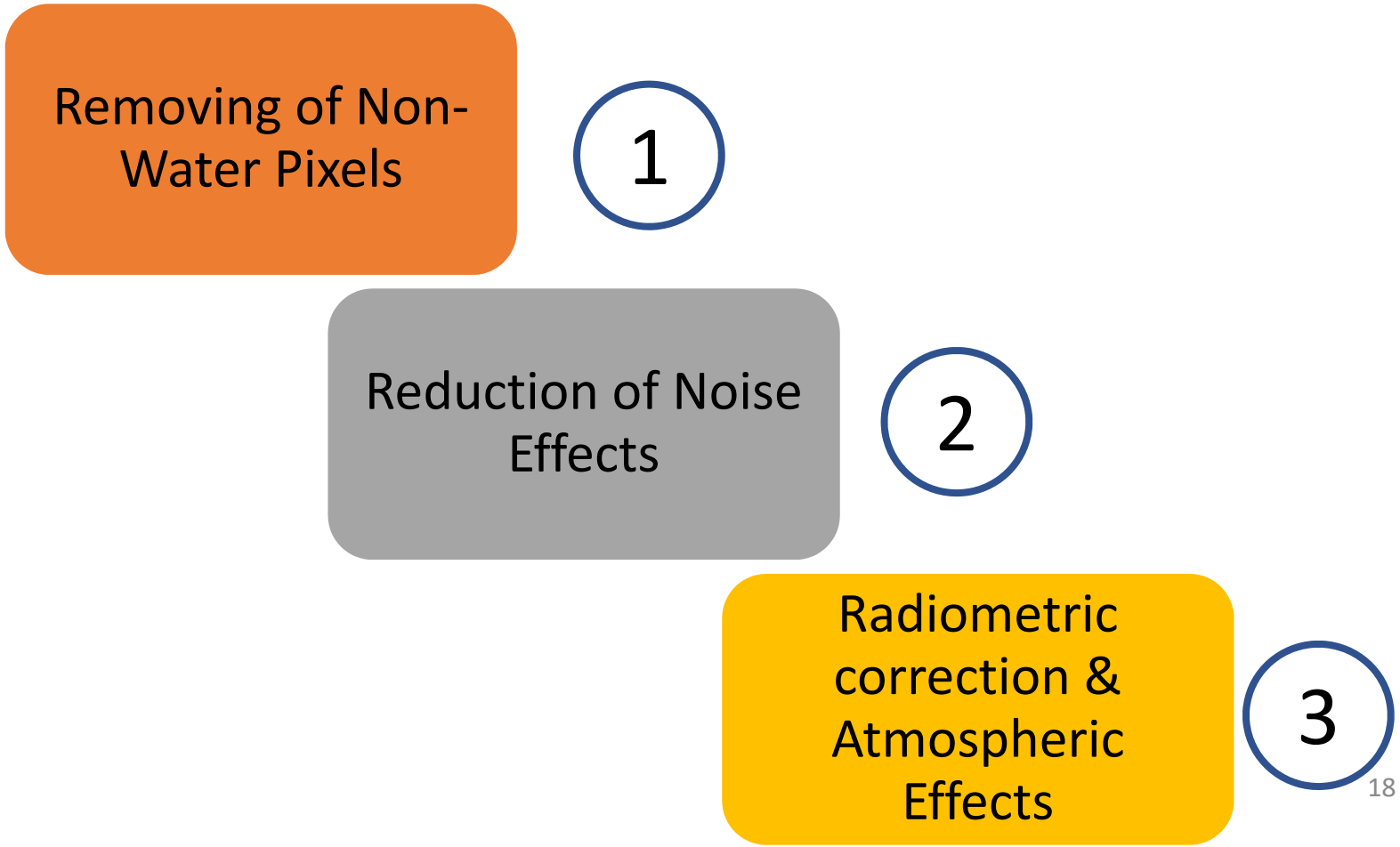
- Create account at USGS Earth Explorer website

  https://earthexplorer.usgs.gov/

- Select scene and time range



Preprocessing of the Landsat TM and ETM+ Images

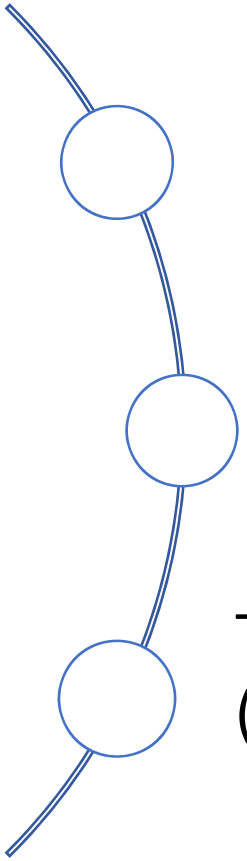


Model for SD calculation

$$SD = \exp(-1.18 + 3.45(TM1/TM2) - 2.67(TM3/TM2))$$

where;
TM1, TM2 and TM3 : atmospherically-corrected reflectance at Landsat band 1, band 2 and band 3

Data extraction and Long-term trend of the Secchi Disk Depth

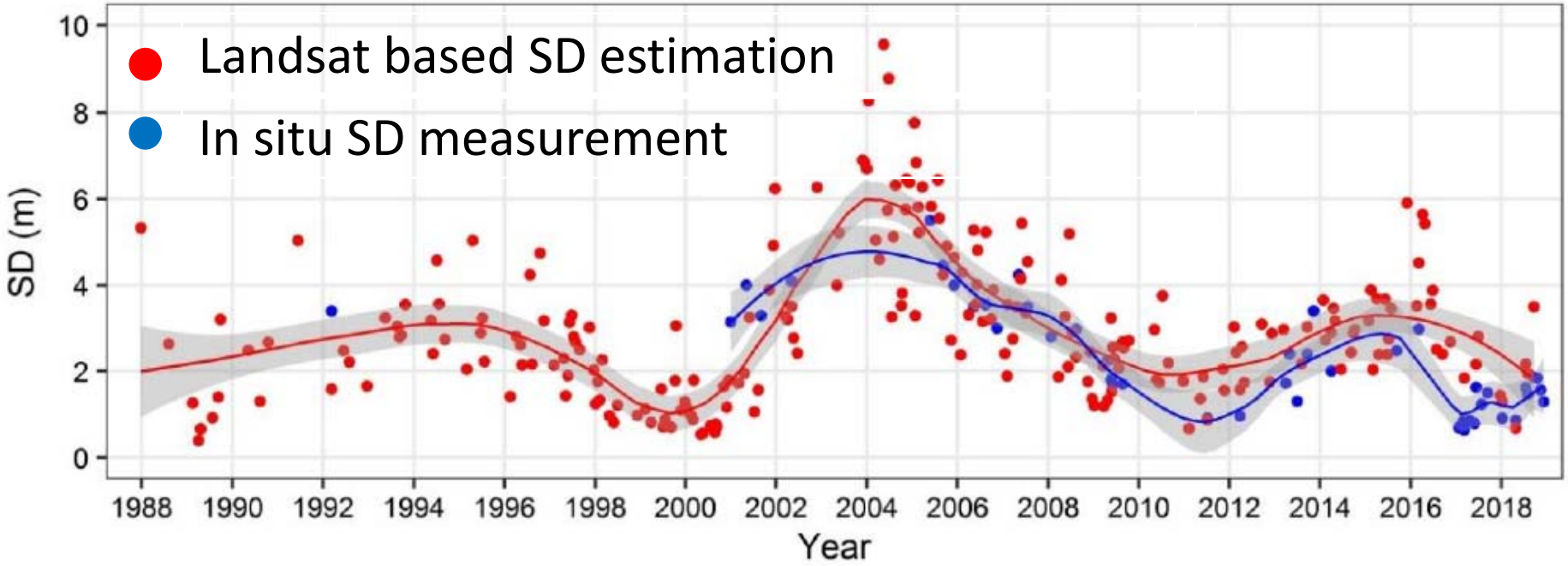


excluded Landsat images with <50% available water pixels

Plot data estimated and In situ SD data

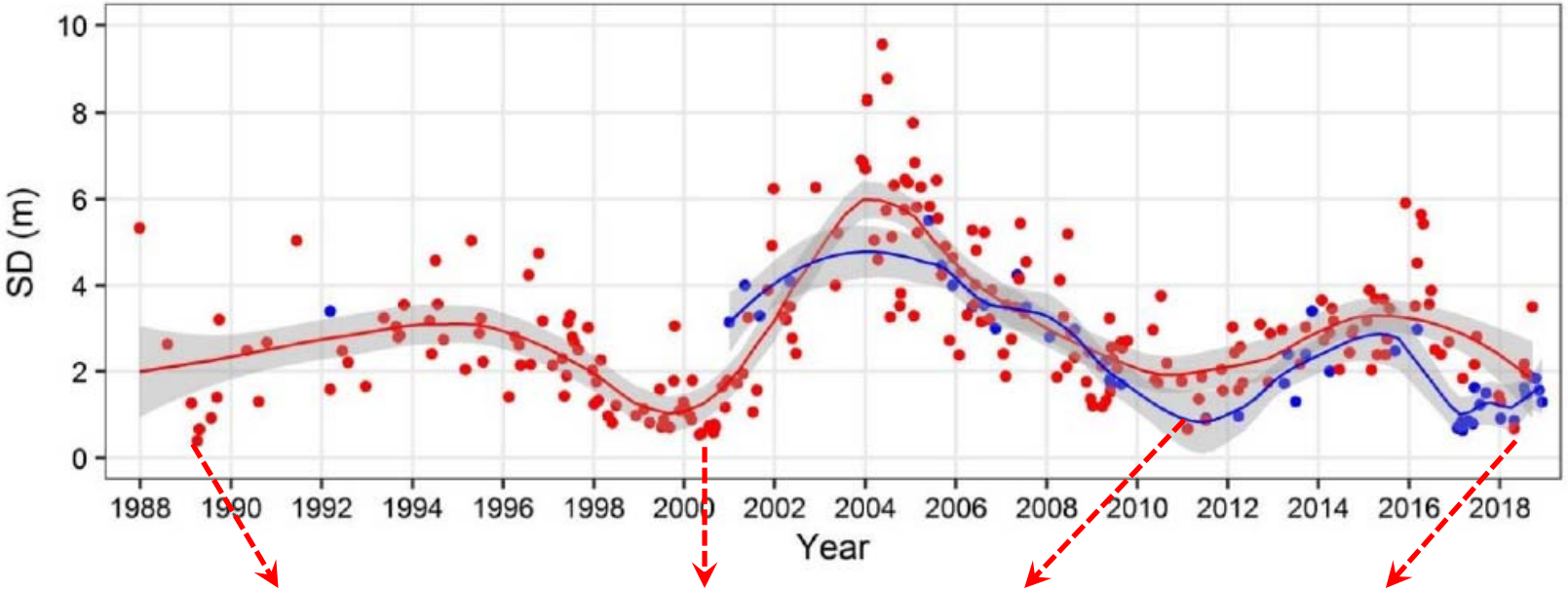
Time-series data analyses using LOESS
(the **L**ocally w**E**ighted **S**catterplot **S**moothing)
in R language.

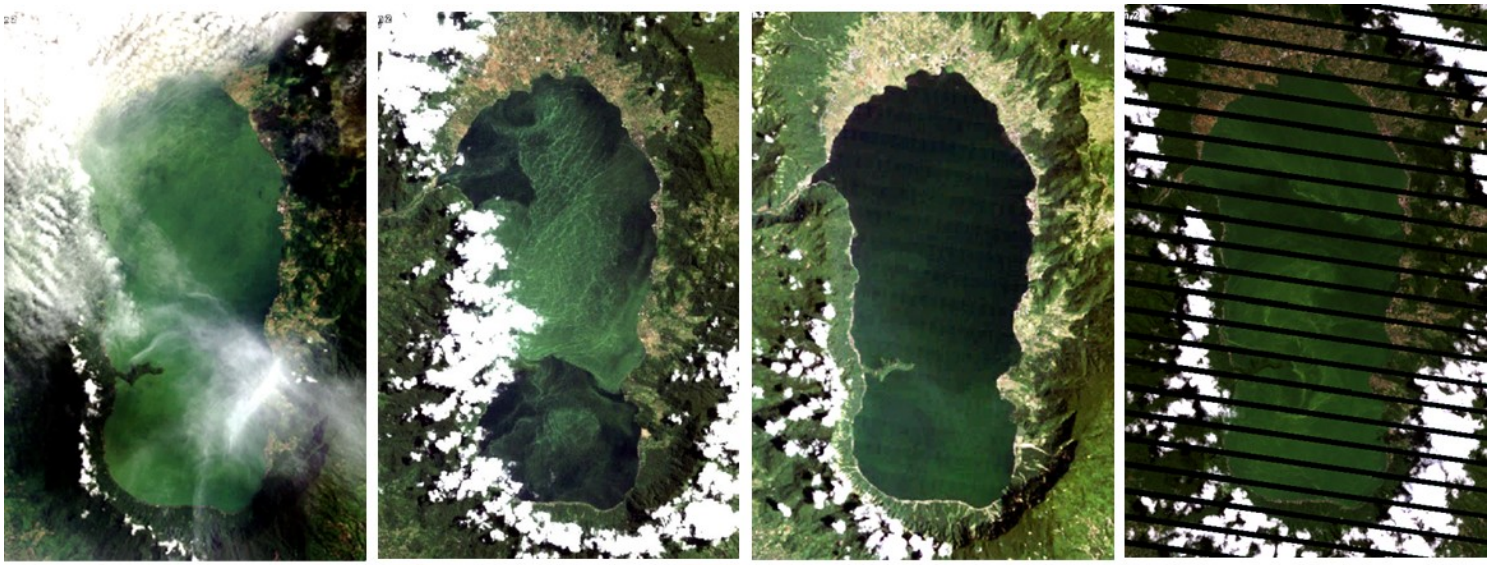
Case Study:
Long-term changes of SD
in Lake Maninjau from 1987 to 2018



Dynamic SD fluctuation both from Landsat based estimation and In situ measurements

Low SD and blooming algae





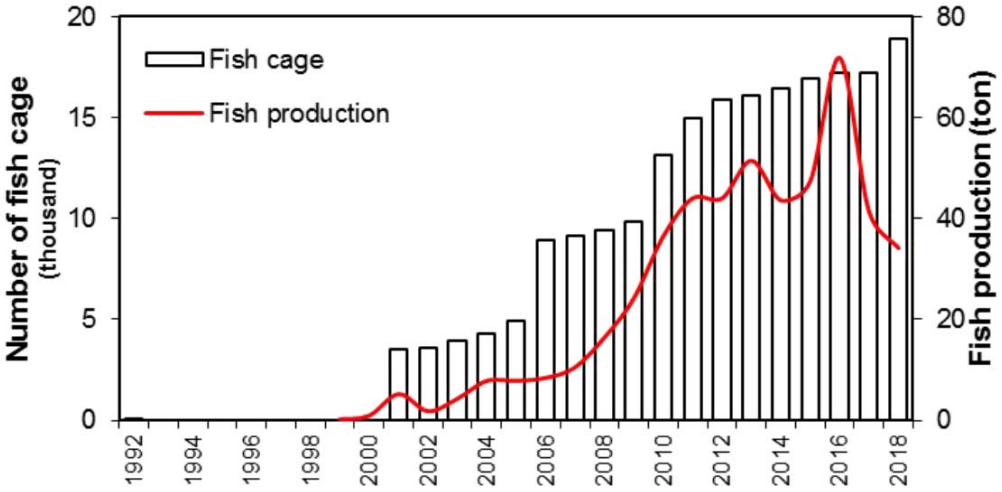
1989-04-04, L5
SD = 0.3 m

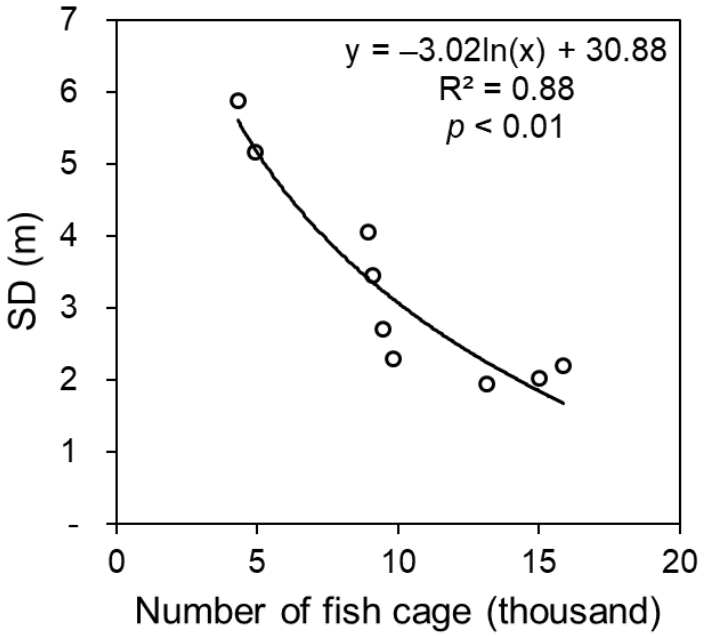
2000-08-24, L5
SD = 0.58 m

2011-02-12, L5
SD = 0.66 m

2018-04-28, L7
SD = 0.67 m

Major driving factor of water transparency in lake Maninjau





No significant change in the watershed

Internal factor influence SD

Voluntary SD measurement

As an alternative to deal with the scarcity of in situ water quality data

More eyes observing the lakes

More data to fill the data gap

Build local people awareness

Future work and collaboration

Combine	Combine SD estimation using Landsat Images and In situ SD measurement
Produce	Produce a databased for each lake and reservoir in Indonesia
Provide	Provide useful long-term SD data for lake managers and policy-makers.

Based on paper:

Title : Long-Term Change of the Secchi Disk Depth in Lake Maninjau, Indonesia Shown by Landsat TM and ETM+ Data

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