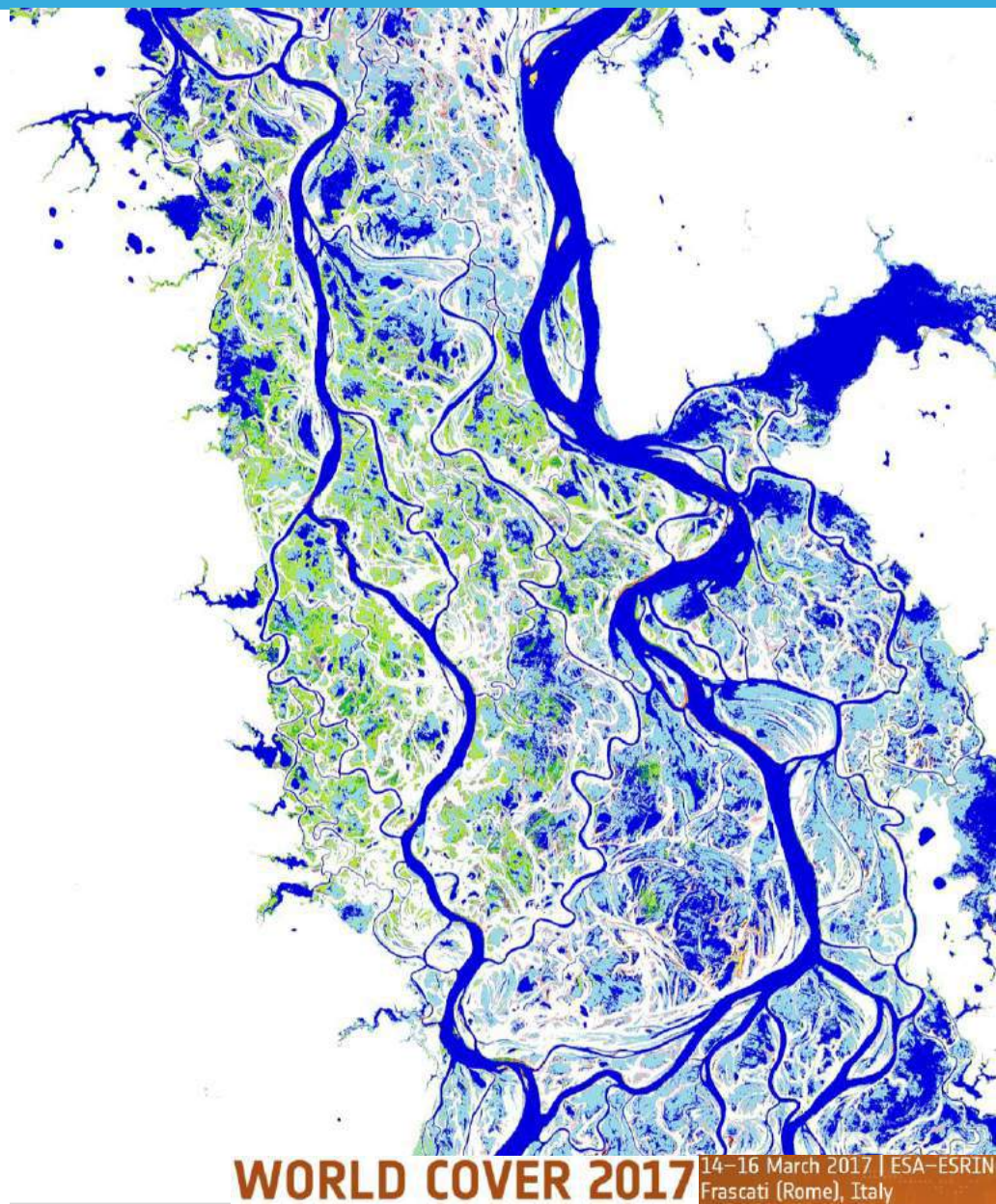
Global scale mapping of the when and where of inland and coastal waters over 32 years at 30m resolution

Jean-Francois Pekel

European Commission - Joint Research Centre

Google Earth Engine

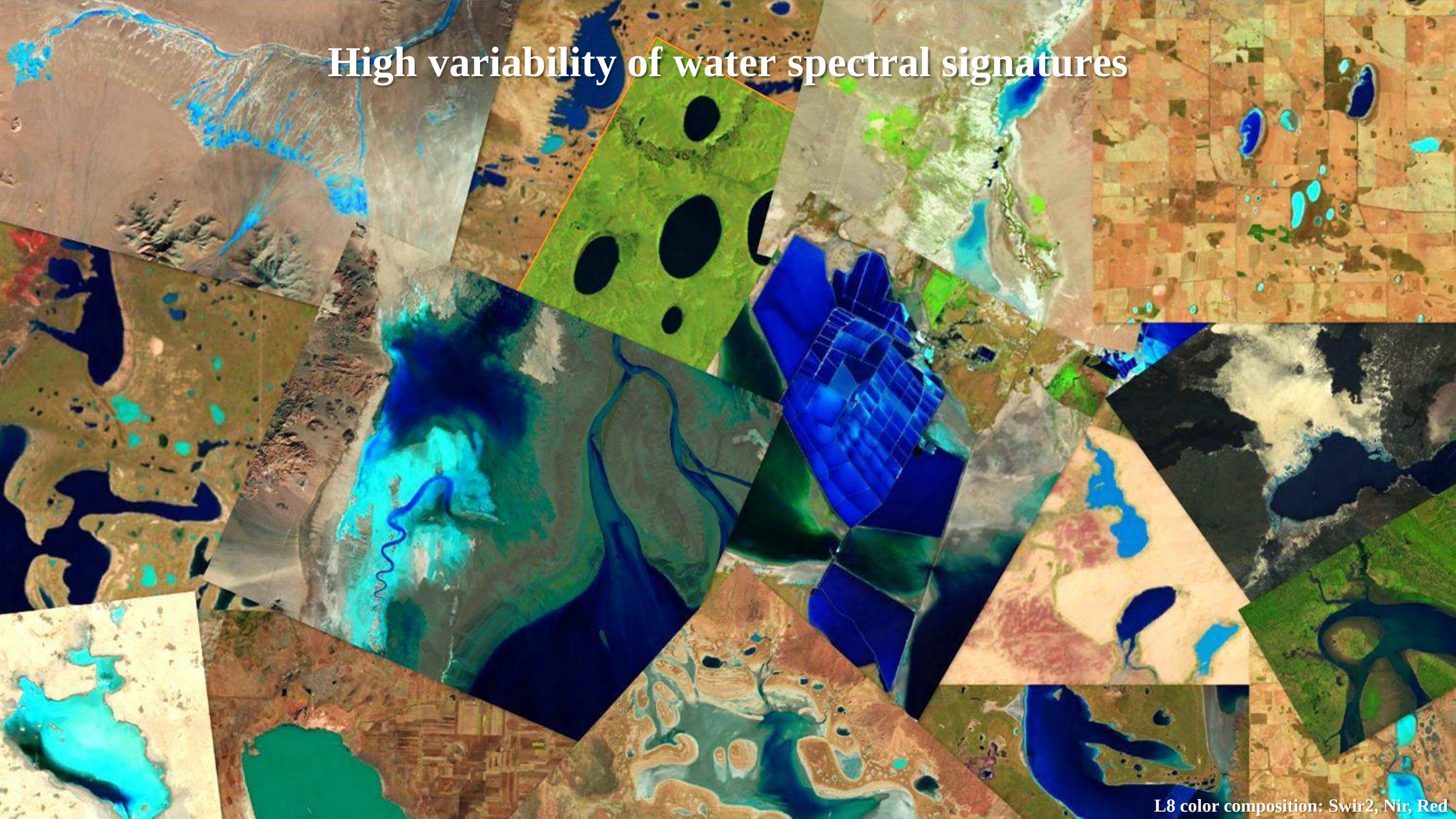


Objectives

Addressing some of the key questions related to the surface water dynamics

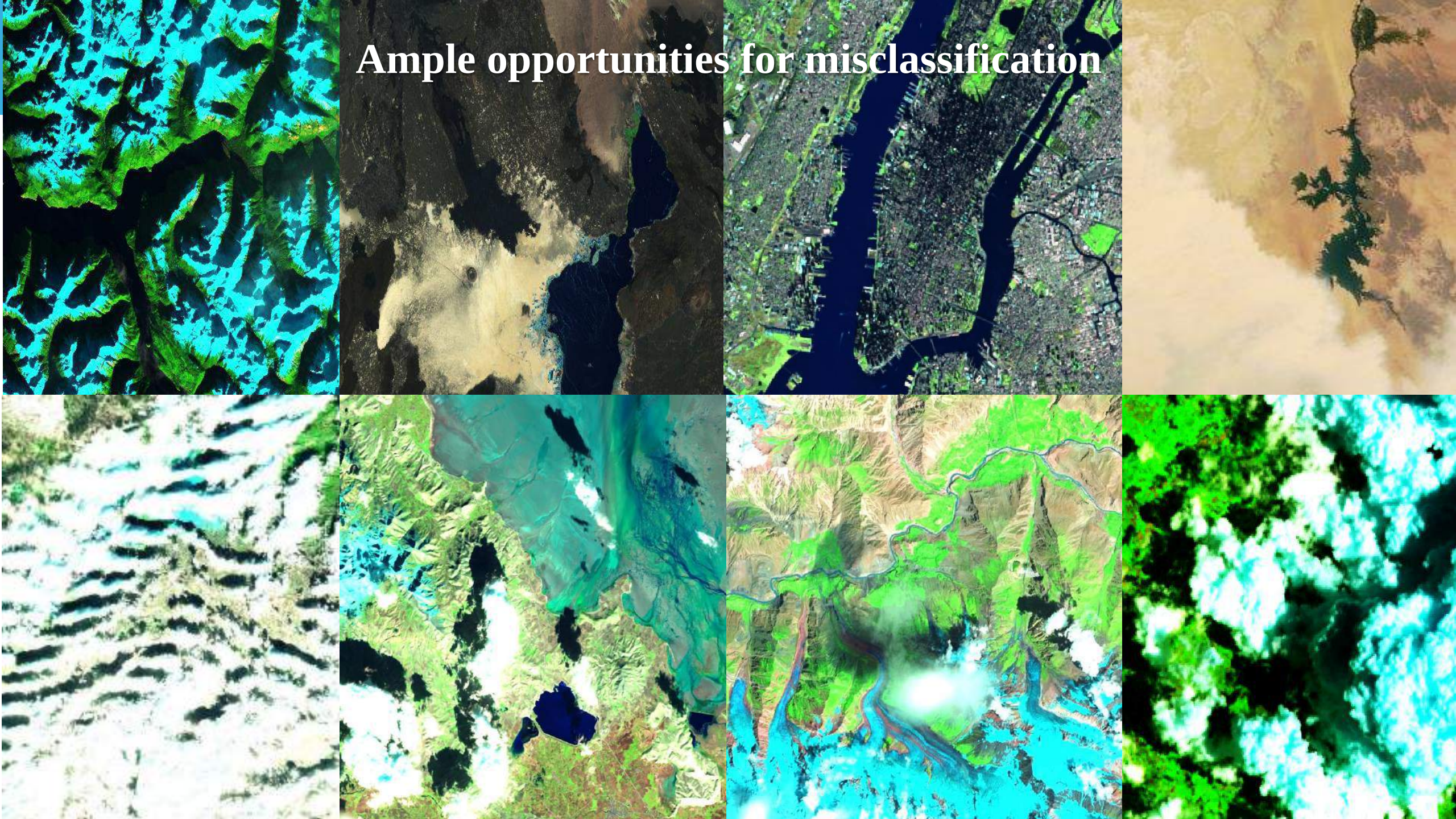
- Where has surface water occurred over the past 3 decades ?
- When do water bodies fill and empty ?
- What about their inter and intra-annual variability ?
- How likely is it to find water in any given place and month ?
- When and where have new/ex water-bodies formed/disappeared ?
- What form did changes take, in terms of seasonality and persistence ?
- What about trends ?

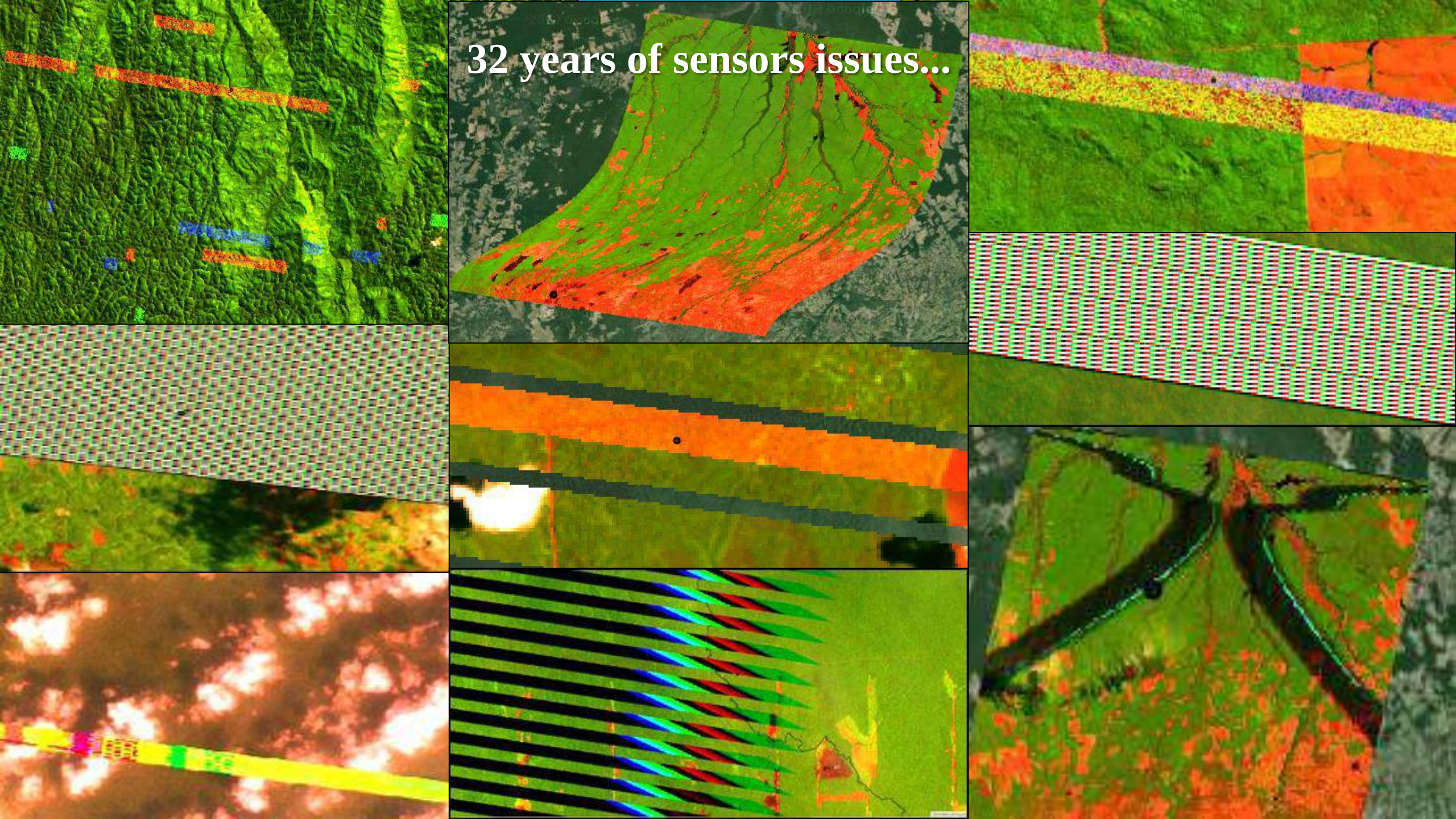
High variability of water spectral signatures



L8 color composition: Swir2, Nir, Red

Ample opportunities for misclassification

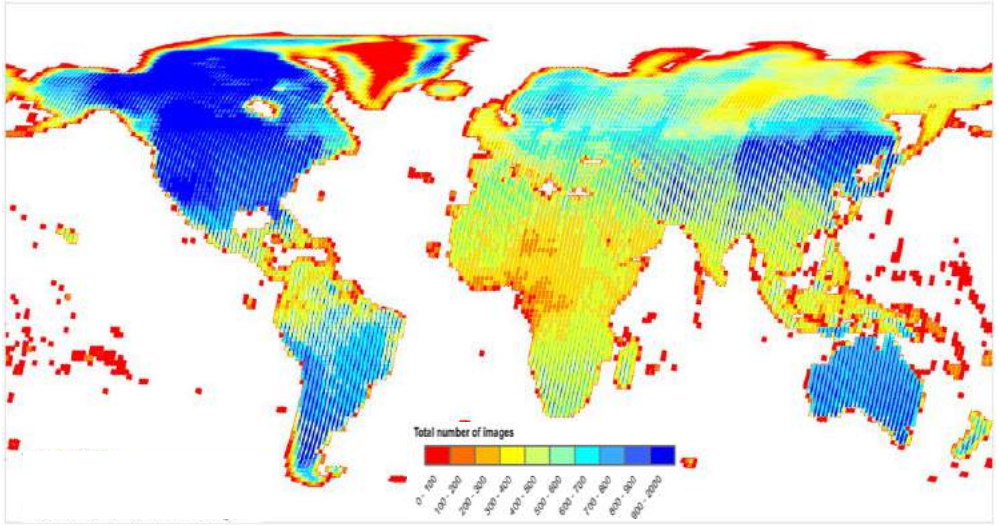



32 years of sensors issues...

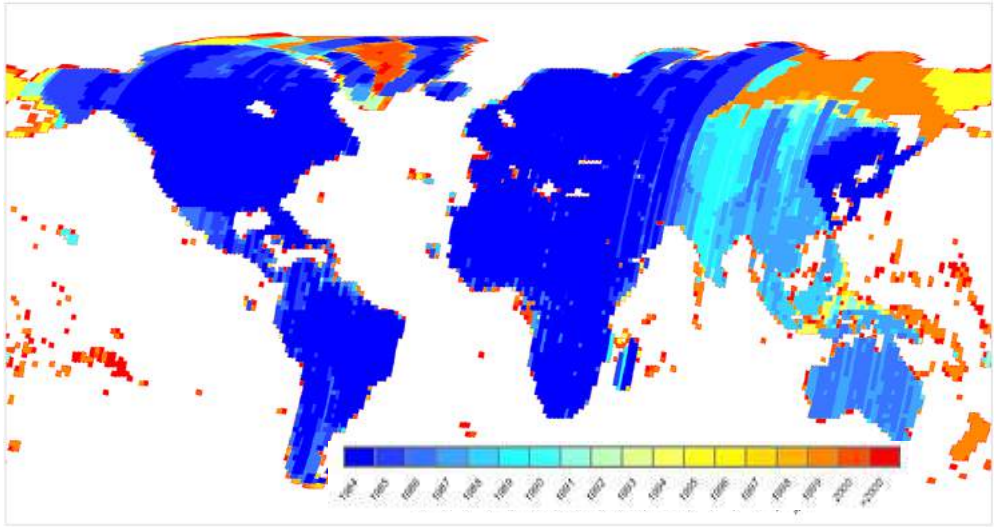
Geographic and temporal unevenness of the archive

European Commission

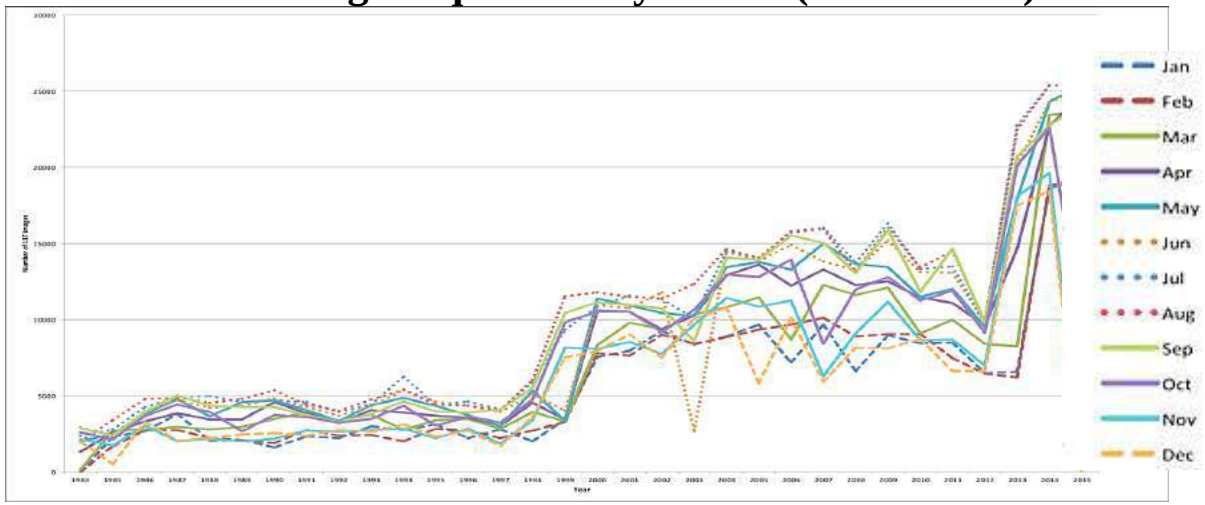
Number of L1T



Year of the first image acquisition



Rate of image acquisition by month (1984 – 2015)



Pixel based classifier

Each pixel of the 3,066,102 Landsat scenes was classified as water, land or non-valid observation

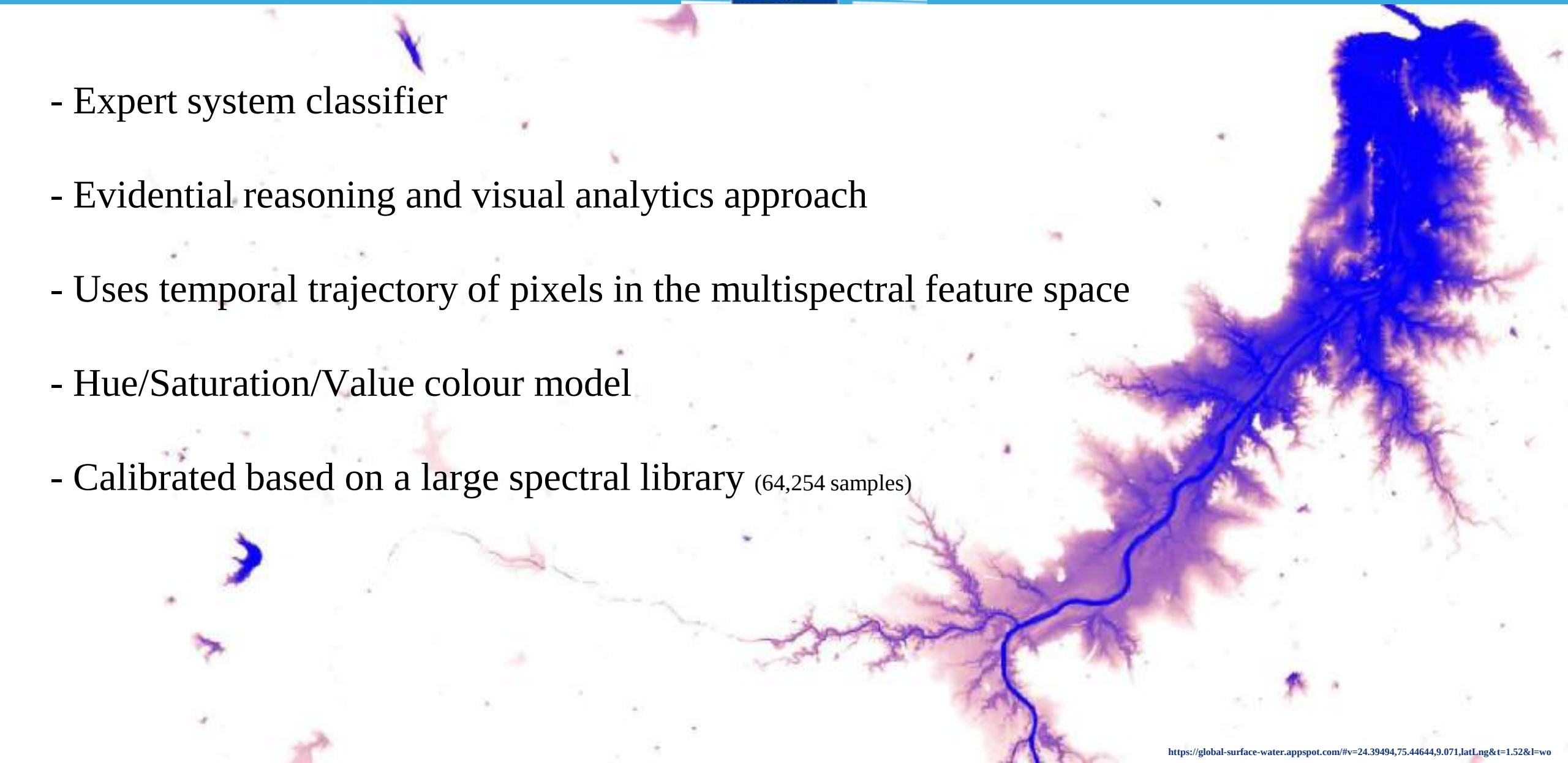
- Expert system classifier

- Evidential reasoning and visual analytics approach

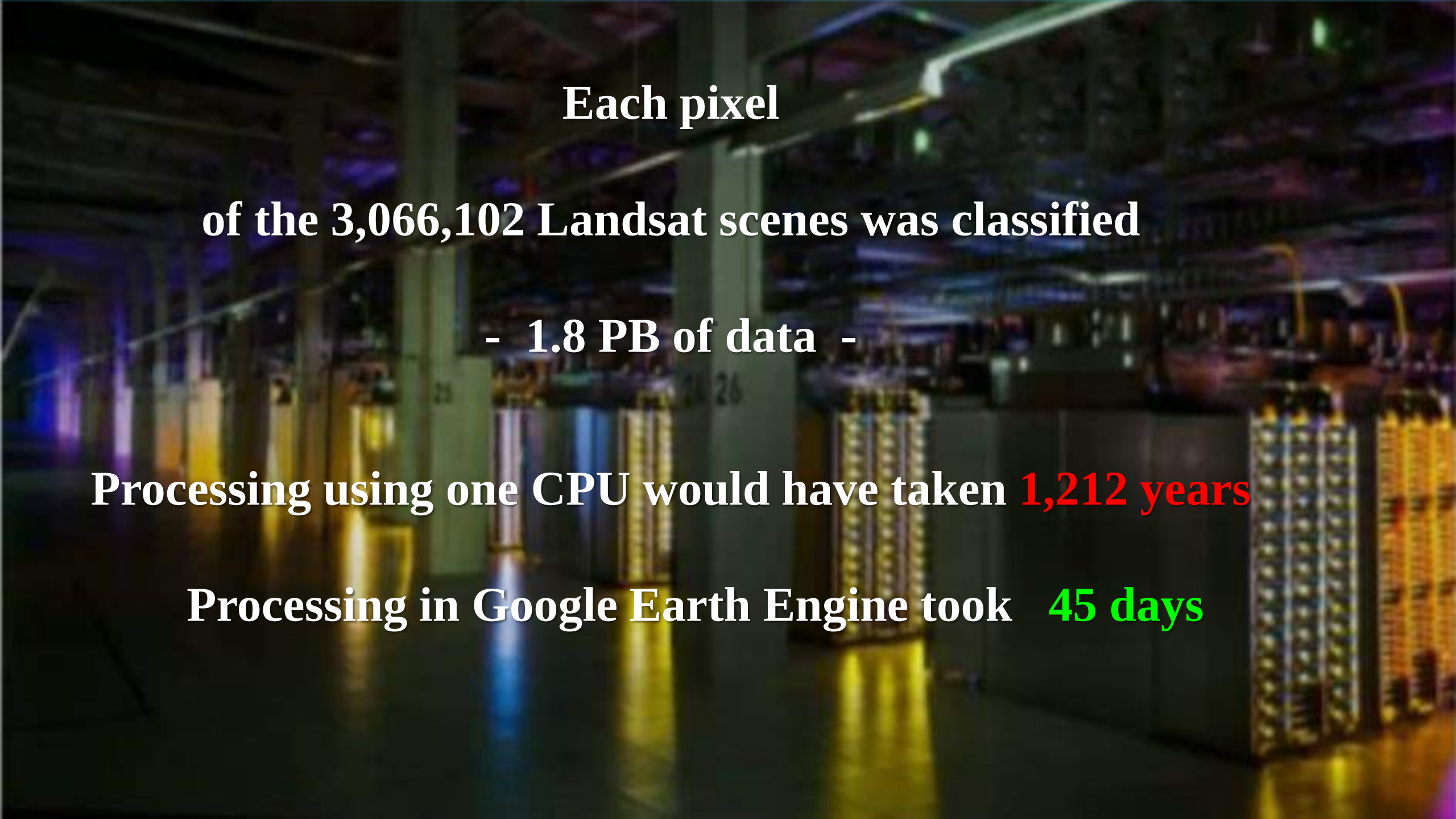
- Uses temporal trajectory of pixels in the multispectral feature space

- Hue/Saturation/Value colour model

- Calibrated based on a large spectral library (64,254 samples)



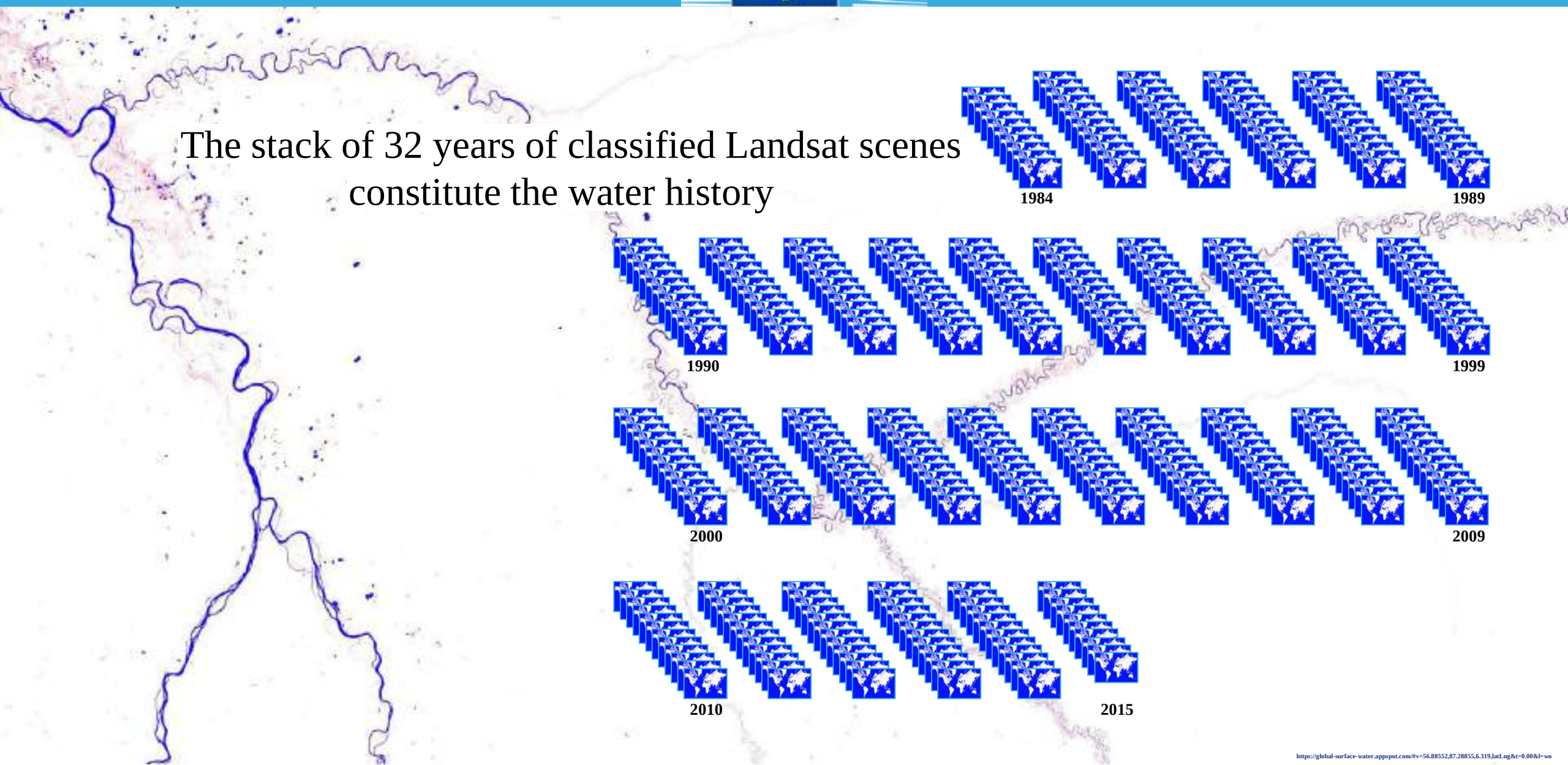
https://global-surface-water.appspot.com/#v=24.39494,75.44644,9.071,latLng&t=1.52&l=wo


Each pixel
of the 3,066,102 Landsat scenes was classified
- 1.8 PB of data -
Processing using one CPU would have taken 1,212 years
Processing in Google Earth Engine took 45 days

Water history

The When and Where
of the water presence across 32 years

The stack of 32 years of classified Landsat scenes constitute the water history



https://global-surface-water.appspot.com/#v=56.88552,87.28855,6.319,latLng&t=0.00&l=wo

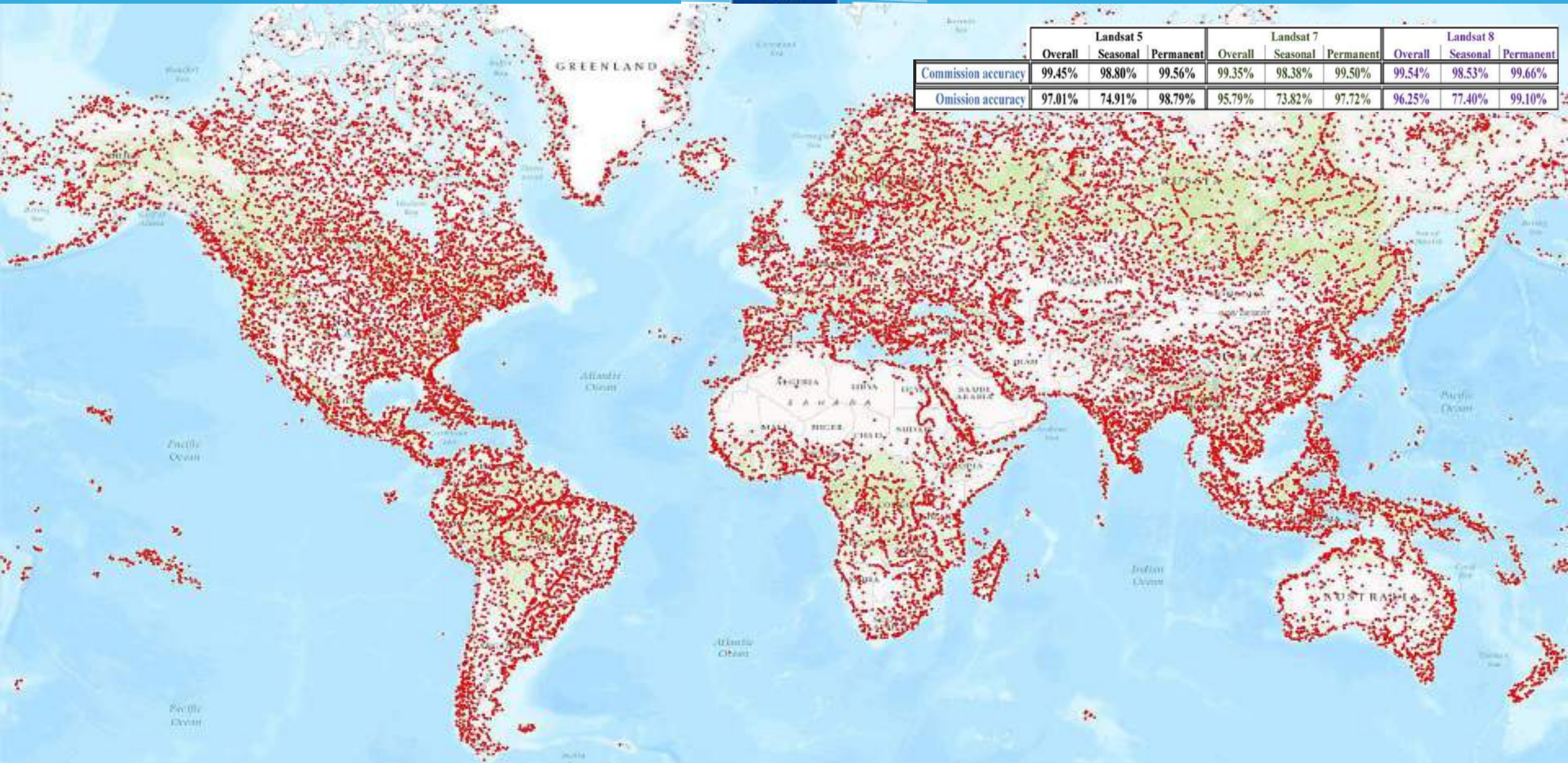
Spatio-Temporal Validation

Based on 40.124 validation samples

Omission < 5%

Commission < 1%

	Landsat 5			Landsat 7			Landsat 8		
	Overall	Seasonal	Permanent	Overall	Seasonal	Permanent	Overall	Seasonal	Permanent
Commission accuracy	99.45%	98.80%	99.56%	99.35%	98.38%	99.50%	99.54%	98.53%	99.66%
Omission accuracy	97.01%	74.91%	98.79%	95.79%	73.82%	97.72%	96.25%	77.40%	99.10%



Thematic Products

The validated water history was used to produce thematic products that document different facets of the surface water dynamics

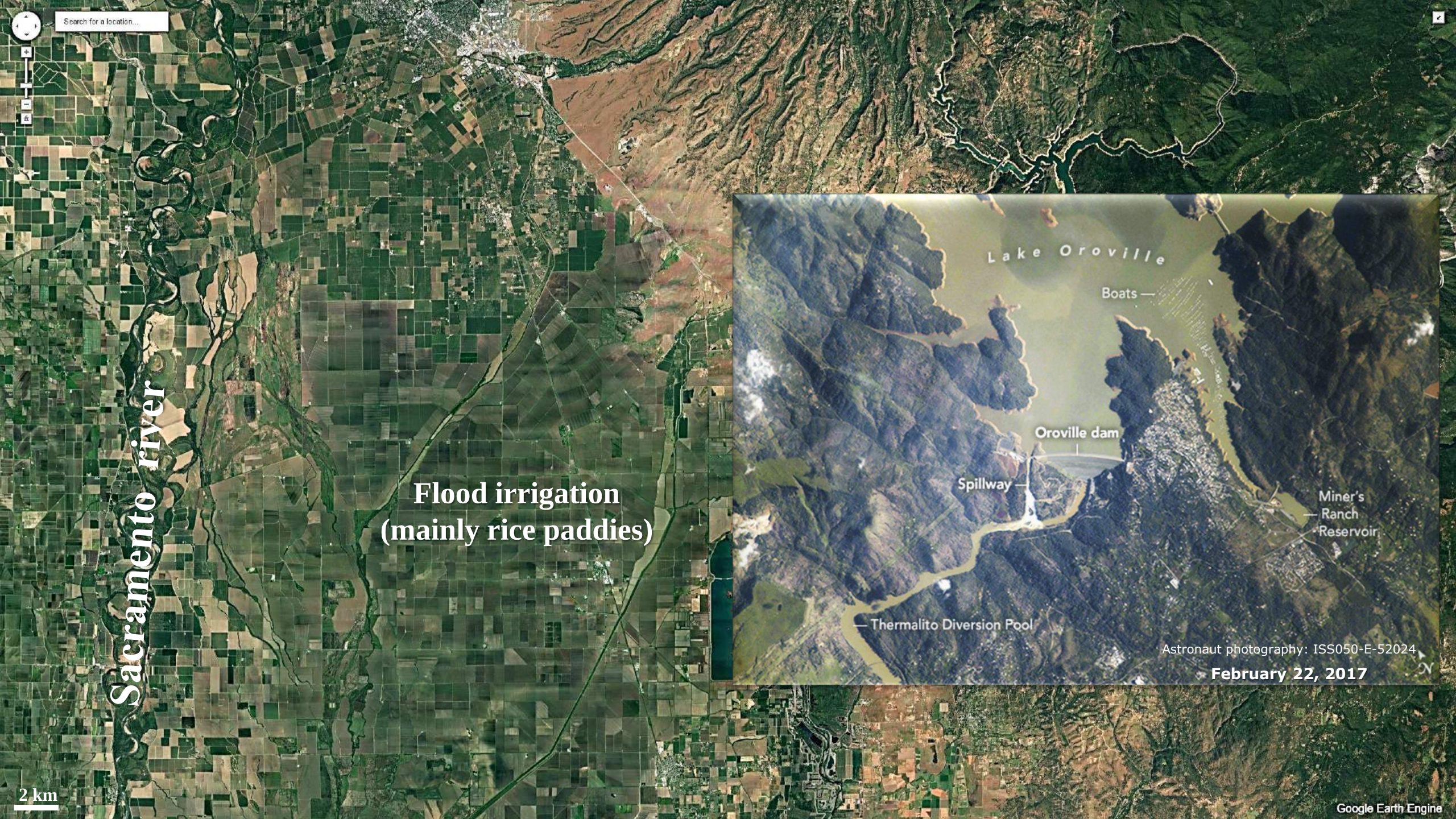
Maps & Temporal Profiles

- Occurrence
- Occurrence Change Intensity
- Seasonality
- Recurrence
- Water Transition
- Max Water Extent

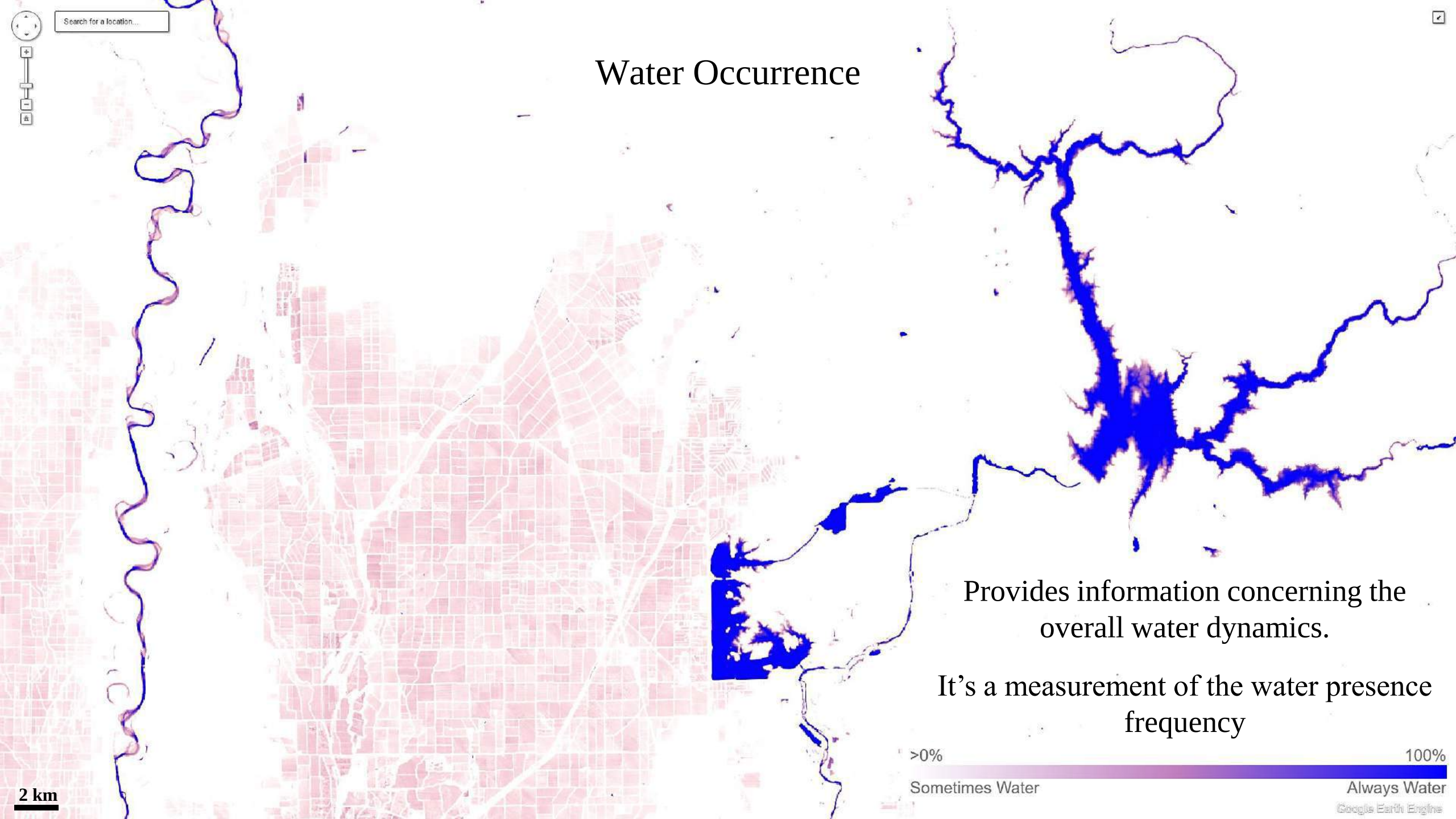
Full monthly water history

(+Metadata layers)

https://global-surface-water.appspot.com/


Search for a location...
Sacramento river
Flood irrigation
(mainly rice paddies)
Lake Oroville
Boats
Oroville dam
Spillway
Miner's
Ranch
Reservoir
Thermalito Diversion Pool
Astronaut photography: ISS050-E-52024
February 22, 2017
2 km
Google Earth Engine

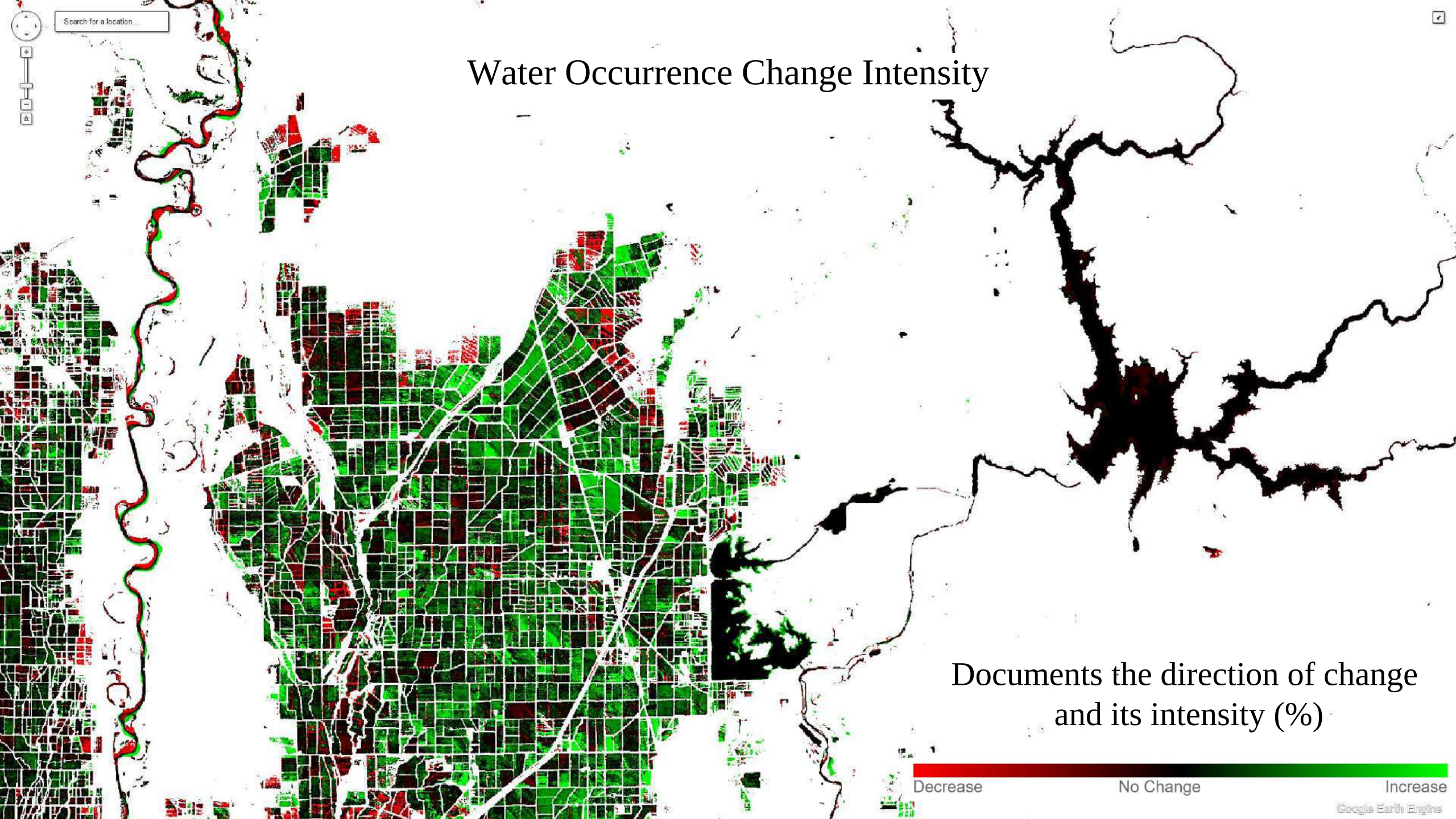
Water Occurrence



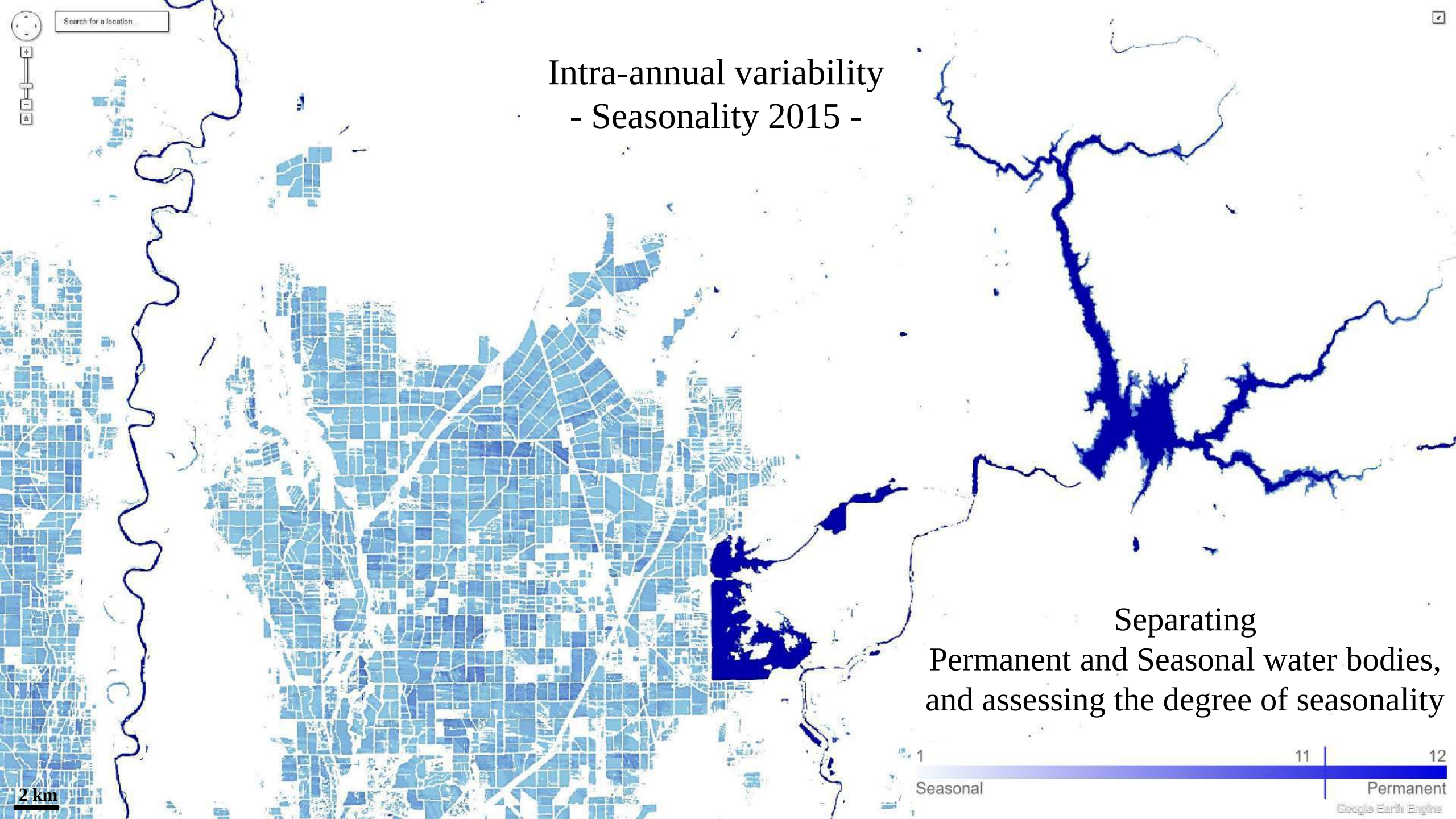
Provides information concerning the overall water dynamics.

It’s a measurement of the water presence frequency

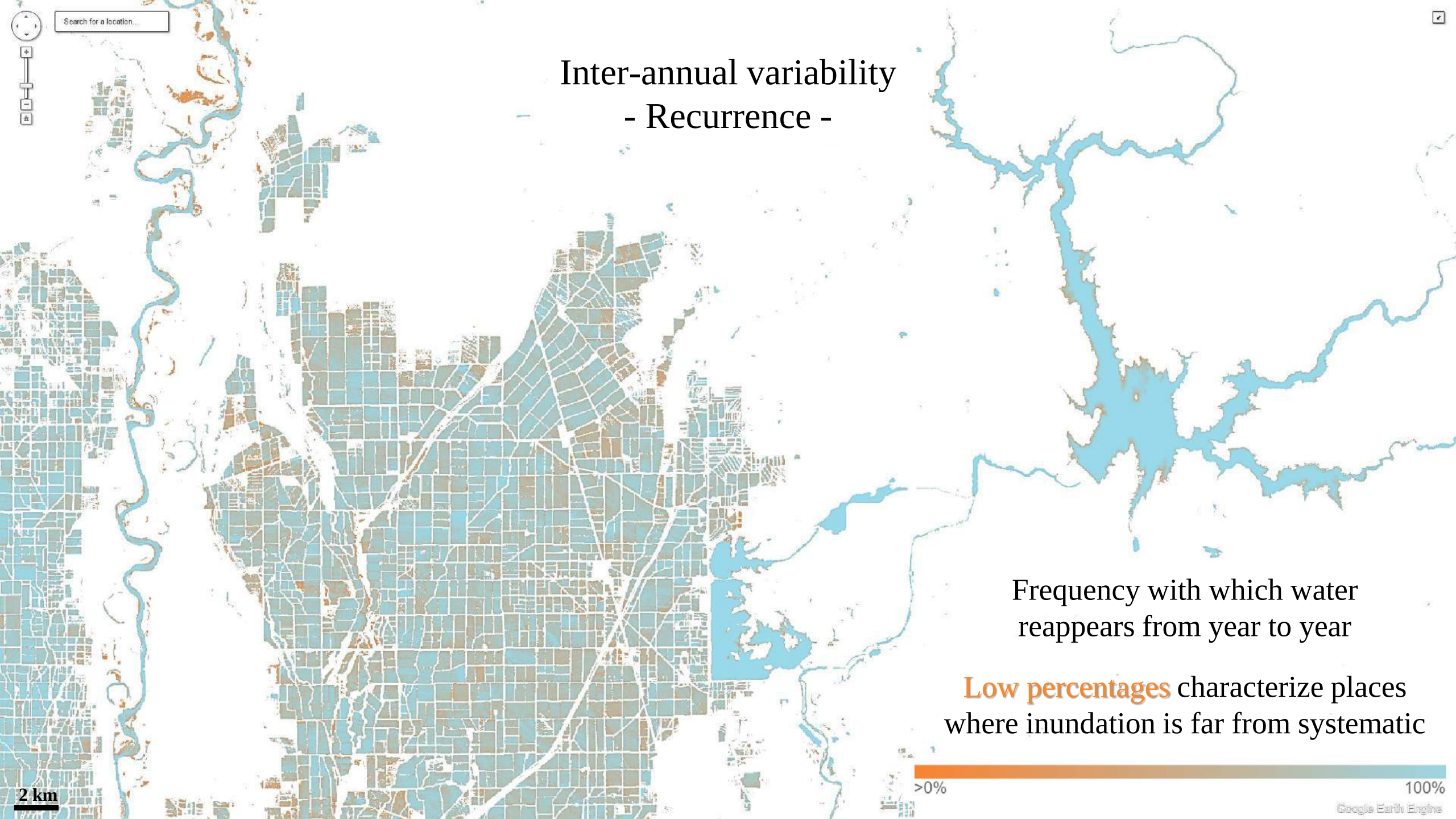
Water Occurrence Change Intensity



Documents the direction of change and its intensity (%)

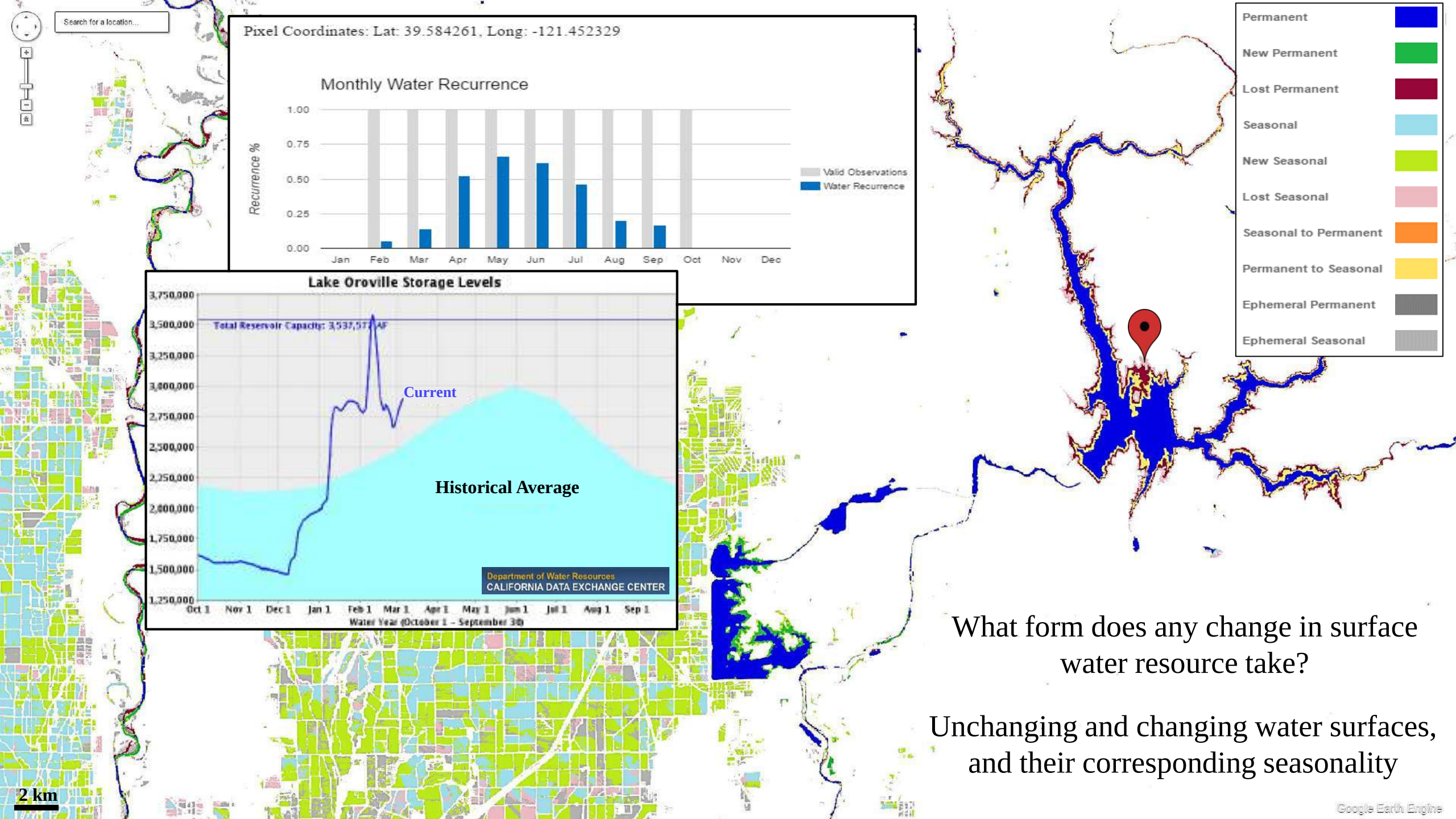

Search for a location...
Intra-annual variability
- Seasonality 2015 -
Separating
Permanent and Seasonal water bodies,
and assessing the degree of seasonality
1
11
12
Seasonal
Permanent
2 km
Google Earth Engine

Inter-annual variability
- Recurrence -



Frequency with which water reappears from year to year

Low percentages characterize places where inundation is far from systematic

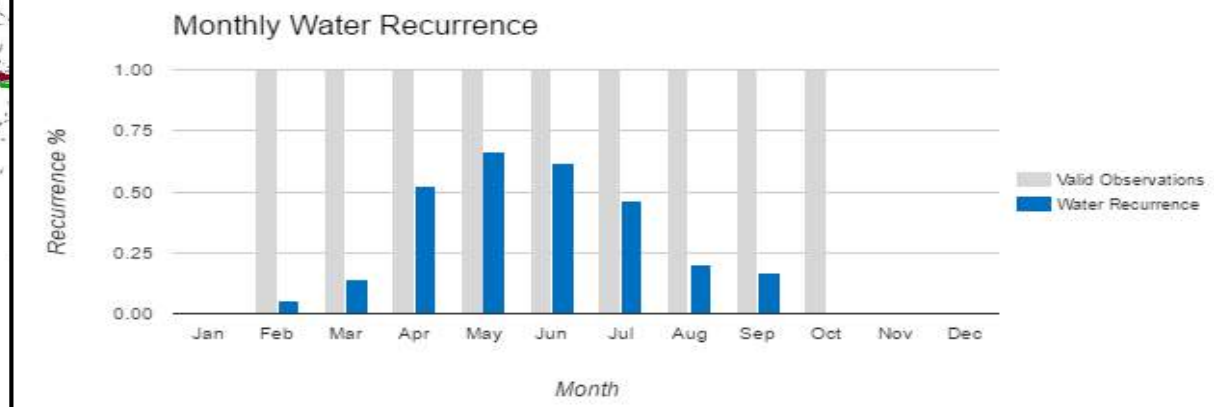


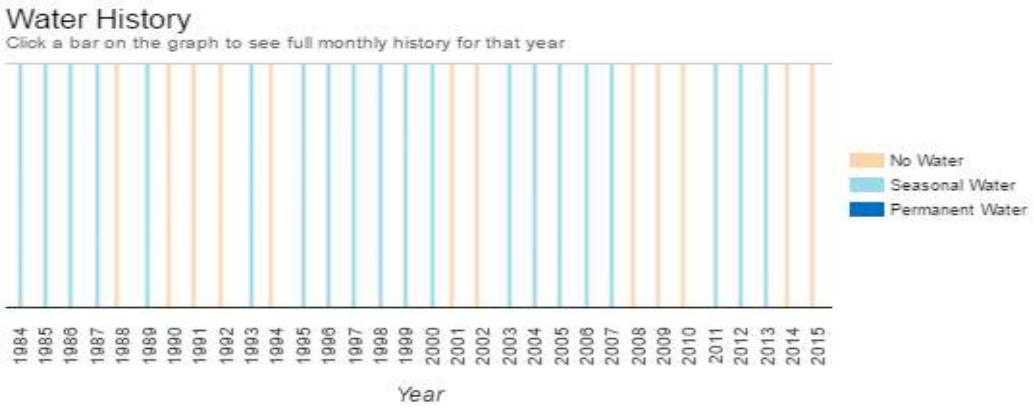
What form does any change in surface water resource take?

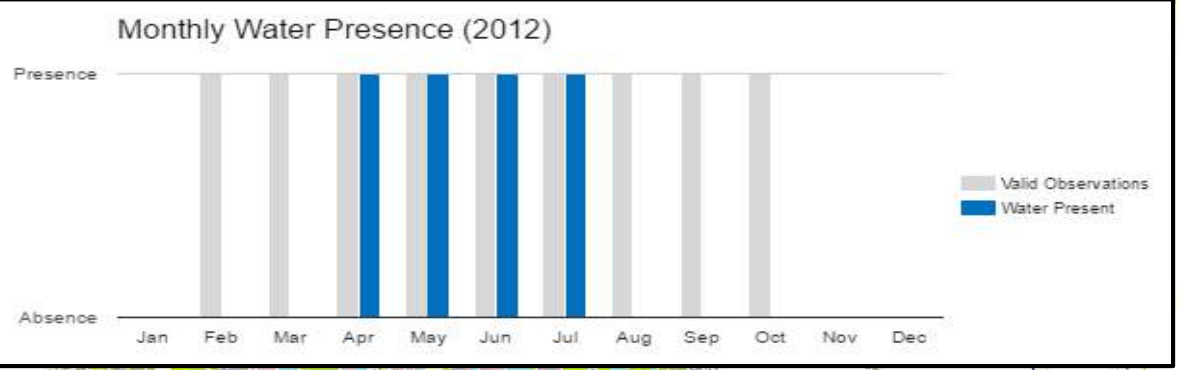
Unchanging and changing water surfaces, and their corresponding seasonality

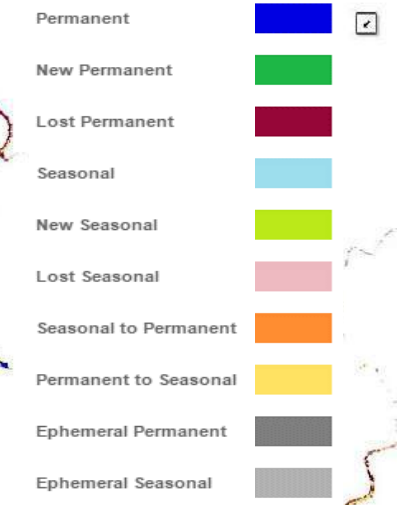
Search for a location...

Pixel Coordinates: Lat: 39.584261, Long: -121.452329





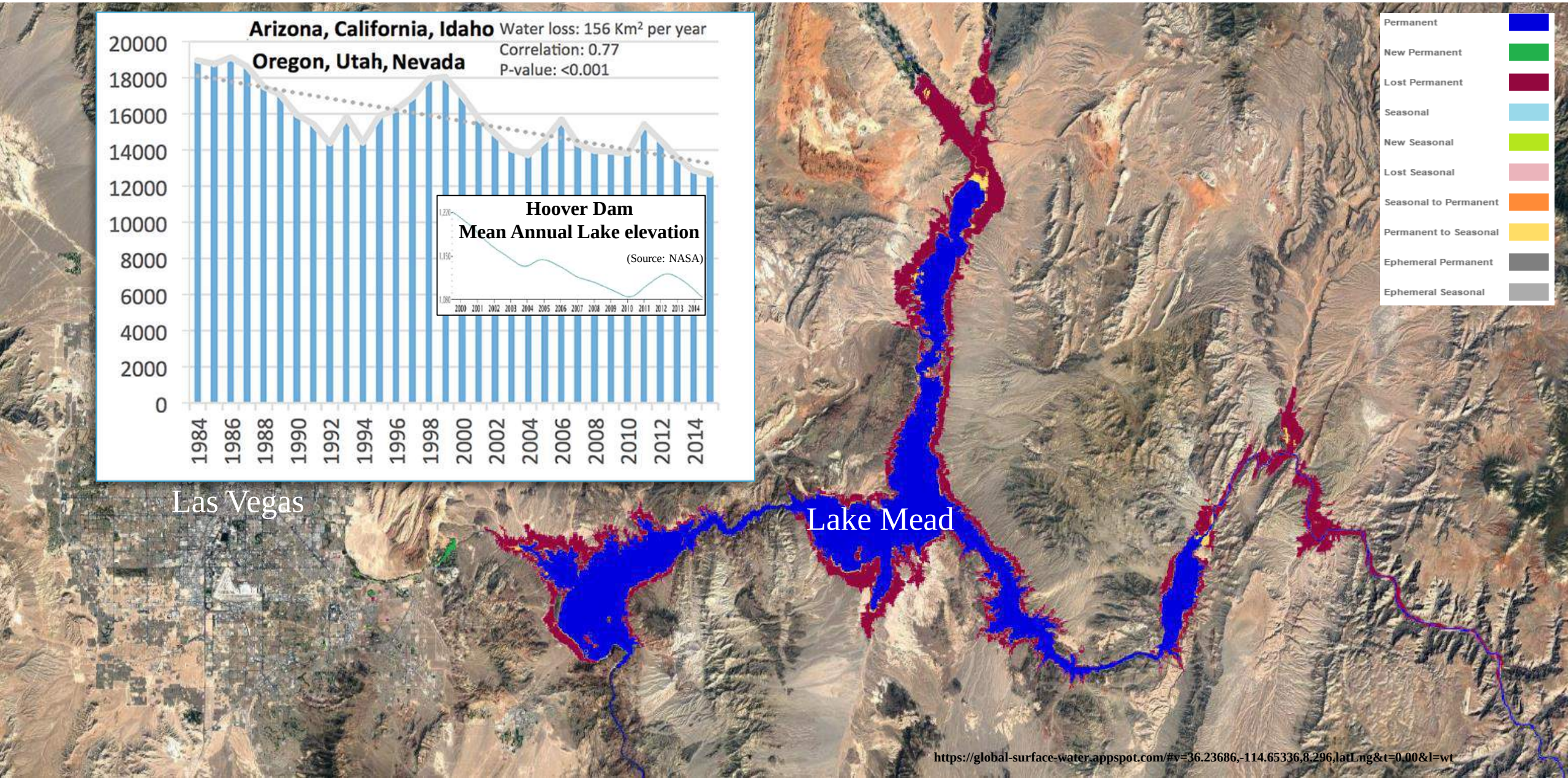




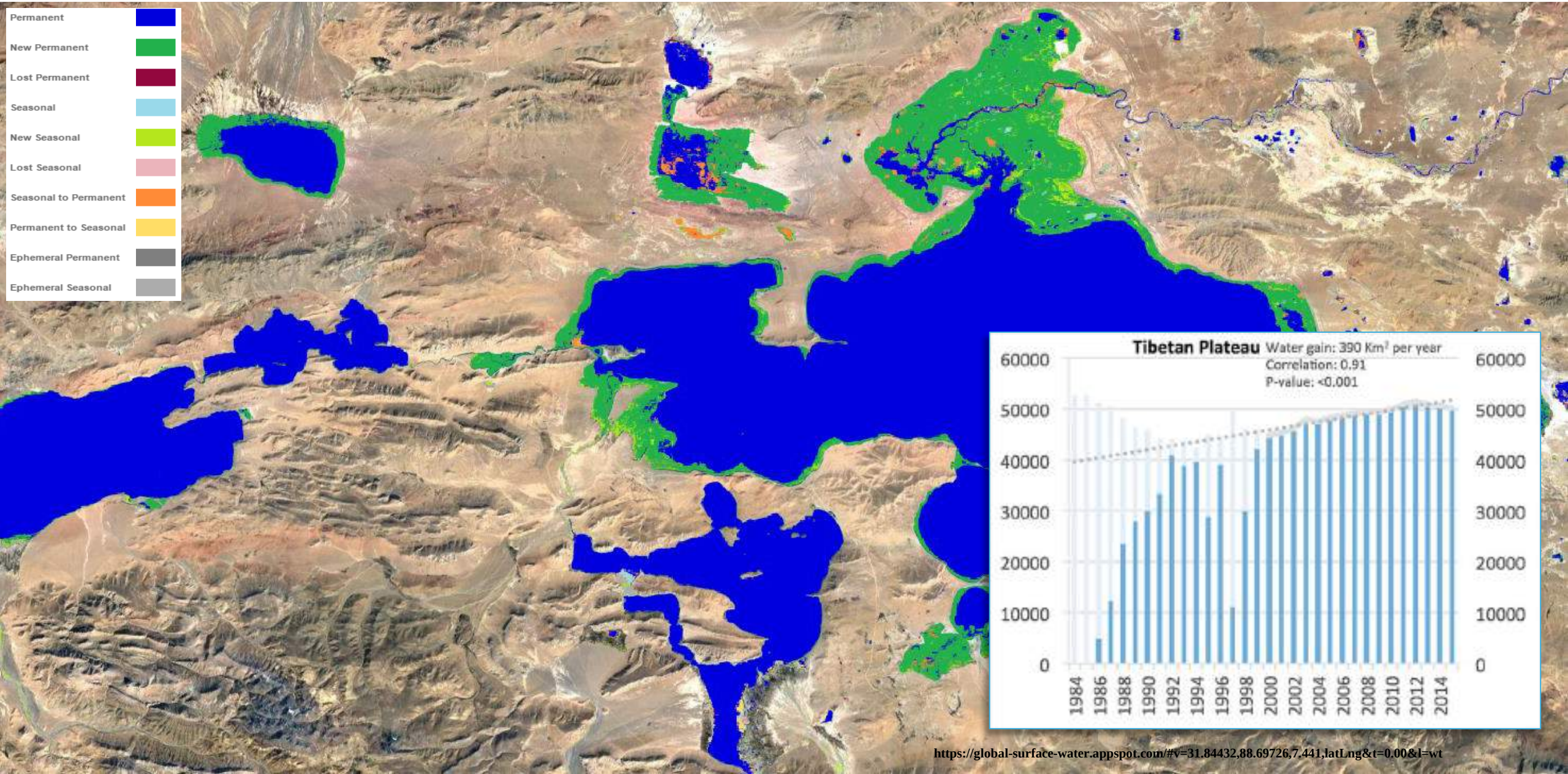
2 km

Google Earth Engine

Drought and sustained demands for water have seen six western states lose more than 6,000 km^2 of their permanent surface water (33%)

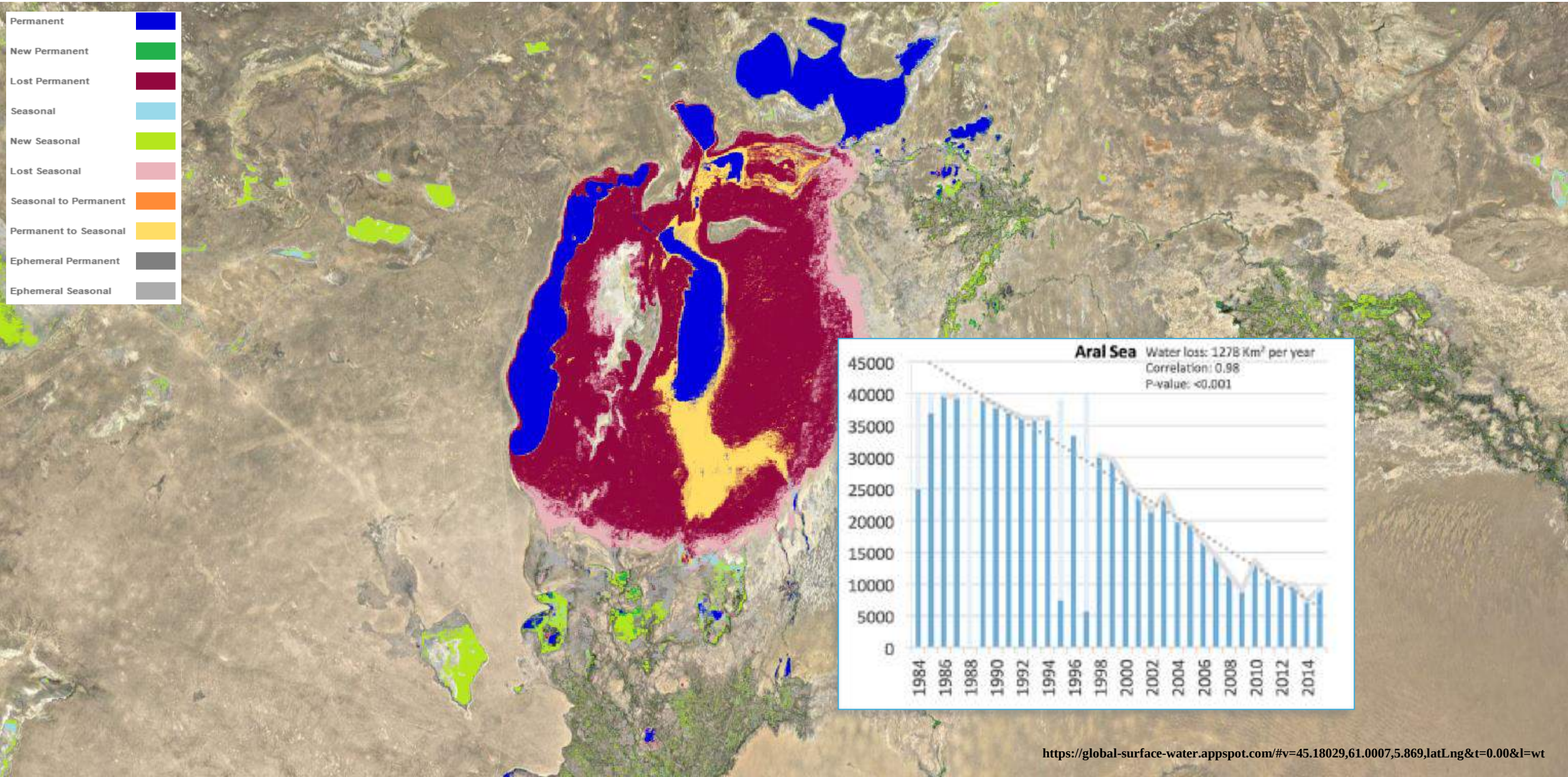


Lakes on the Tibetan Plateau have increased in area by 20% with respect to the 1980s: Grazing land is lost and transport links threatened



https://global-surface-water.appspot.com/#v=31.84432,88.69726,7.441,latLng&t=0.00&l=wt

The Aral Sea has lost around 1200 km^2 per year since 1986
Some recovery is apparent after 2015



https://global-surface-water.appspot.com/#v=45.18029,61.0007,5.869,latLng&t=0.00&l=wt

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LETTER

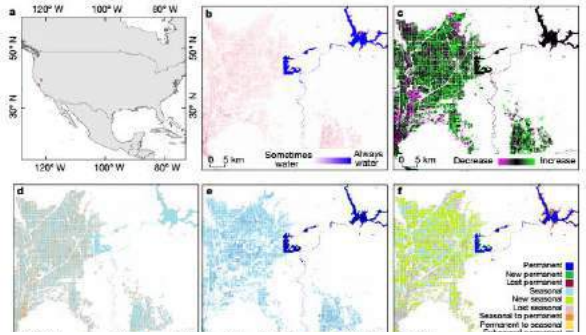
doi:10.1038/nature20584

High-resolution mapping of global surface water and its long-term changes

Jean-François Pekel[1], Andrew Cottam[1], Noel Gorelick[2] & Alan S. Belward[1]

The location and persistence of surface water (inland and coastal) is both affected by climate and human activity[1] and affects climate[2,3], biological diversity[4] and human wellbeing[5,6]. Global data sets documenting surface water location and seasonality have been produced from inventories and national descriptions[7], statistical extrapolation of regional data[8] and satellite imagery[9–12], but measuring long-term changes at high resolution remains a challenge. Here, using three million Landsat satellite images[13], we quantify changes in global surface water over the past 32 years at 30-metre resolution. We record the months and years when water was present, where occurrence changed and what form changes took in terms of seasonality and persistence. Between 1984 and 2015 permanent surface water has disappeared from an area of almost 90,000 square kilometres, roughly equivalent to that of Lake Superior, though new permanent bodies of surface water covering 184,000 square kilometres have formed elsewhere. All continental regions show a net increase in permanent water, except Oceania, which has a fractional (one per cent) net loss. Much of the increase is from reservoir filling, although climate change[14] is also implicated. Loss is more geographically concentrated than gain. Over 70 per cent of global net permanent water loss occurred in the Middle East and Central Asia, linked to drought and human actions including river diversion or damming and unregulated withdrawal[15,16]. Losses in Australia[17] and the USA[18] linked to long-term droughts are also evident. This globally consistent, validated data set shows that impacts of climate change and climate oscillations on surface water occurrence can be measured and that evidence can be gathered to show how surface water is altered by human activities. We anticipate that this freely available data will improve the modelling of surface forcing, provide evidence of state and change in wetland ecotones (the transition areas between biomes), and inform water-management decision-making.

Between any two points in time, part of the Earth's surface is constantly underwater and part is never underwater, with the remainder fluctuating between these extremes. Coastlines and lake and river boundaries advance and retreat, rivers meander, new permanent lakes form and



DOI: 10.1038/nature20584

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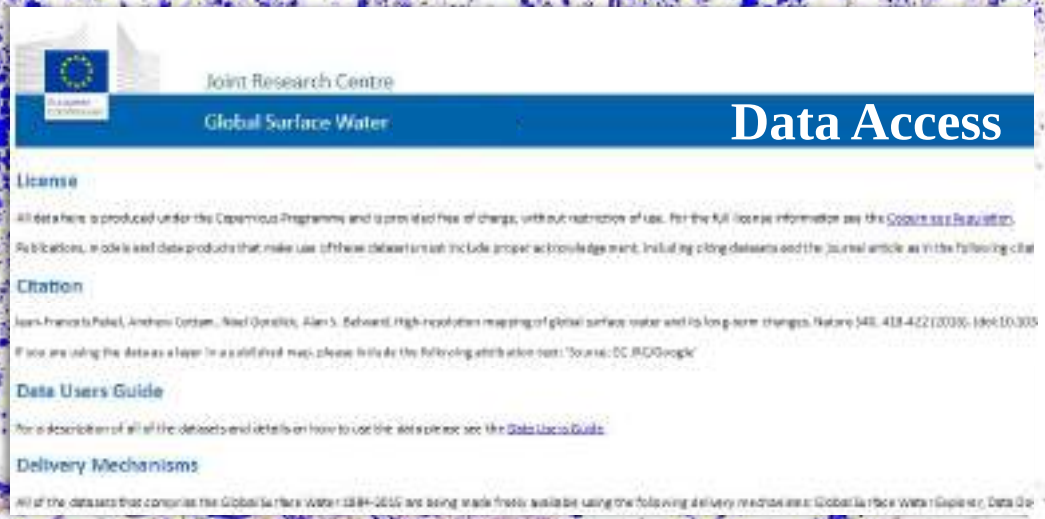

https://global-surface-water.appspot.com/#v=62.06733,72.3967,6,045,latLng&t=0.00&l=wo

Thank you!