

Remotely Sensing Cities and Environments

Lecture 4: Policy applications

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PDF PDF presentation

How to use the lectures

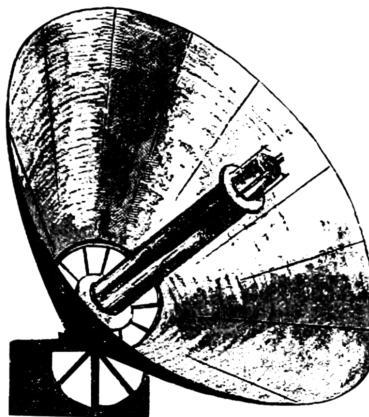
- Slides are made with [xaringan](#)
-  In the bottom left there is a search tool which will search all content of presentation
- Control + F will also search
- Press enter to move to the next result
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- Pressing the letter [o](#) (for overview) will allow you to see an overview of the whole presentation and go to a slide
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Lecture outline

Part 1: Example applications

Part 2: Policy challenges



Source:Original from the British Library. Digitally enhanced by rawpixel.

Before we can explore policy we really need to look at what
remotely sensed data can provide answers to...



So...a brief overview...but of course this depends on the data
you are using



Data from sensors

Depends on a the combination of spectral bands, resolutions + cost.

- Multi-temporal land cover (or land use) mapping
- Spectral signatures / libraries*
- Change detection - e.g. urban or forest
- Vegetation stress - illegal logging
- Precipitation
- Elevation models (or point data) - such as LiDAR
- Temperature
- Night time lights (urban development)
- Forest fire monitoring / predicting / "hot spot" detecting
- Pollution monitoring
- Drought indices
- Informal housing detection
- Water level data - monitoring
- Building or network outline (polygon / line) extraction
- Environmental monitoring (e.g. Aral Sea)
- Estimations of resources - forest, water, snow, ice, green space



Different wavelengths show us different things...

Band	Wavelength	Useful for mapping
Band 1 - coastal aerosol	0.43-0.45	Coastal and aerosol studies
Band 2 - blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation; penetrates thin clouds
Band 8 - Panchromatic	0.50-0.68	15 meter resolution, sharper image definition
Band 9 - Cirrus	1.36-1.38	Improved detection of cirrus cloud contamination
Band 10 - TIRS 1	10.60-11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 - TIRS 2	11.50-12.51	100 meter resolution, improved thermal mapping and estimated soil moisture

Source:[USGS](#)

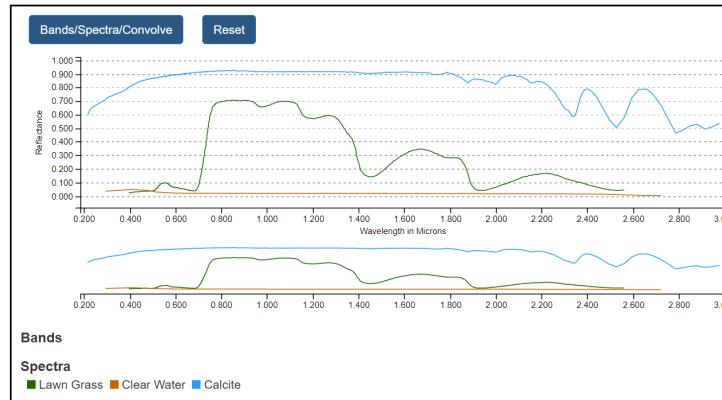
Spectral Characteristics Viewer

The Spectral Characteristics Viewer allows users to determine which satellite bands are best suited for their research application.

How to use the Spectral Characteristics Viewer

1. Click on the "Bands/Spectra/Convolve" button and select the bands from the available satellite instrument(s) to view how they measure the intensity of the wavelengths (colors) of light (also known as Relative Spectral Response -RSR).
2. From the "Spectra" tab select from minerals, vegetation, water or coating-rocks to plot their spectral response alongside the bands from the satellite instrument(s).
3. Click "Close" to view the spectral characteristics results.

To capture spectral characteristics results please use system and web browser print functions.



Source:[USGS](#)

Urban expansion

Sensor

- Landsat

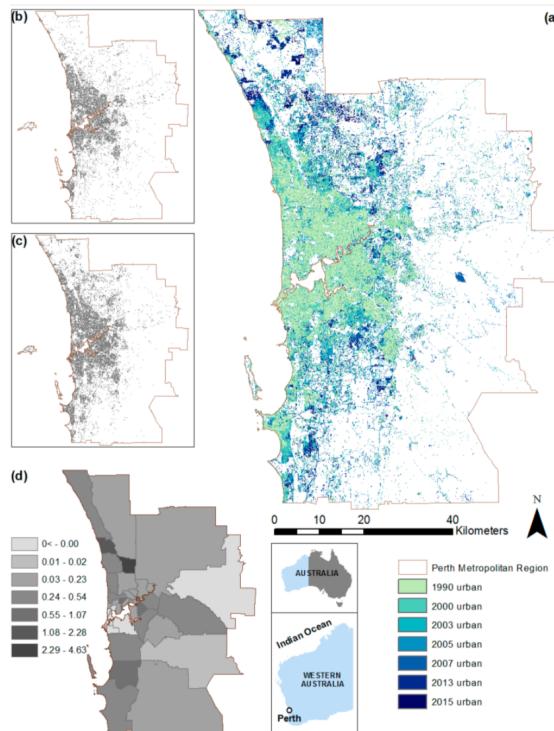


Figure 2. Urban expansion within the Perth Metropolitan Region (PMR) between 1990 and 2015. Vast urban growth has been observed in PMR with graduating colours exhibiting outward expansion (a); (b) and (c) exhibit static snapshots of urban extent from 2000 (b) and 2015 (c); whilst (d) depicts percentage of urban change per subnational administrative boundary (Local Government Area; LGA). Source: [MacLachlan et al. 2017](#)



Air pollution and LULC

Sensors

- Sentinel-3 Sea and Land Surface Temperature
- Sentinel-5 Precursor Major Air Pollutants

LULC transformation on air pollution, increase MAP (Major Air Pollutants) and LST

- Used regression...LULC as independent (explanatory) and LST, pollution etc were dependent
- Honeycombing - hex grids for different sensor data

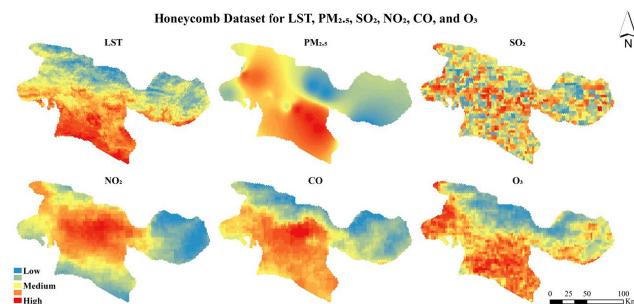


Fig. 2. The classified honeycomb dataset for LST, PM₂₋₅, SO₂, NO₂, CO, and O₃. Source: Fuldal and Alta, 2021



Land Use and (?) Land Cover (LULC)



Urban green spaces

Sensors / data

- Landsat (medium res 17%)
- Sentinel
- LiDAR \$
- High spatial resolution (38%) \$
- High + medium res = 9%

Studies

- Accessibility to urban green spaces - usual kind of stuff
- Also, now types of vegetation - DEM, elevation models and relationship to well being and health
- Google street view! - sky view factor and iTree
- Google Earth Engine - Compare health benefits in relation to green space over 25 cities
- Vegetation health - targeted intervention
- Landscape indexes - mean patch size, patch density and edge density

Remote sensing of urban green spaces: A review. Source: [Shahtahmassebi et al. 2021](#)



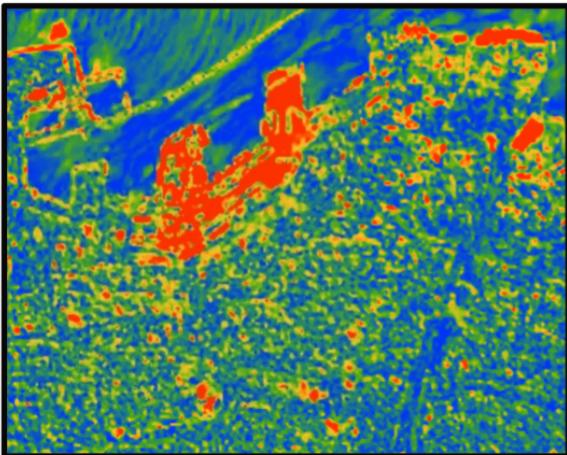
Disaster response / preparedness

Sensor

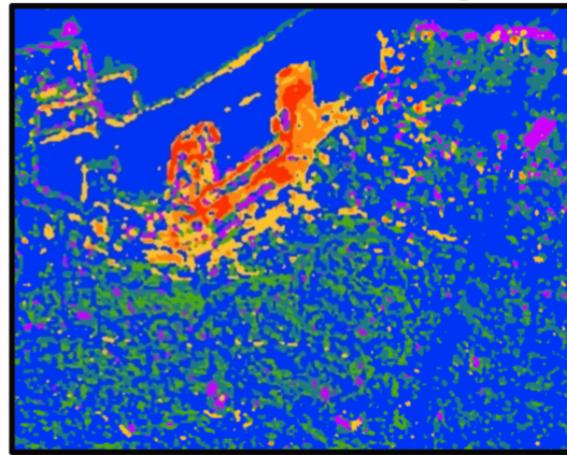
Sentinel-2 spectral imagery

- Image difference (post event - pre-event)
- View-shed analysis (building outlines / DEM)

Absolute Difference

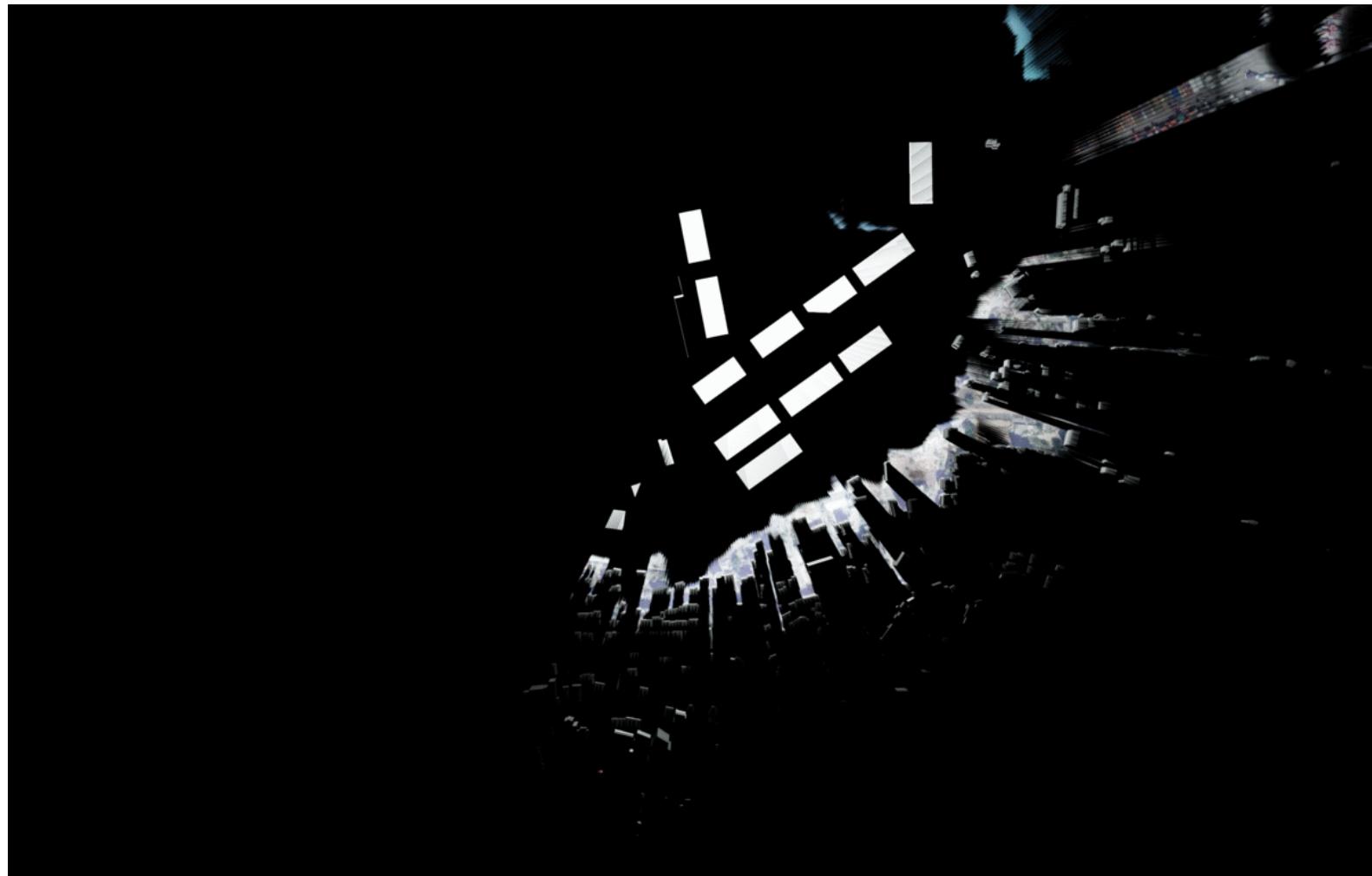


X-Means Clustering



Building a 3D Model of the Beirut Explosion. Source:[Ollie Ballinger](#)

Disaster response / preparedness 2



Building a 3D Model of the Beirut Explosion. Source:[Ollie Ballinger](#)

Synthetic Aperture Radar (SAR)

Covered more in the last week....

Some of the next few slides taken from the last week**



SAR background

Synthetic Aperture Radar:

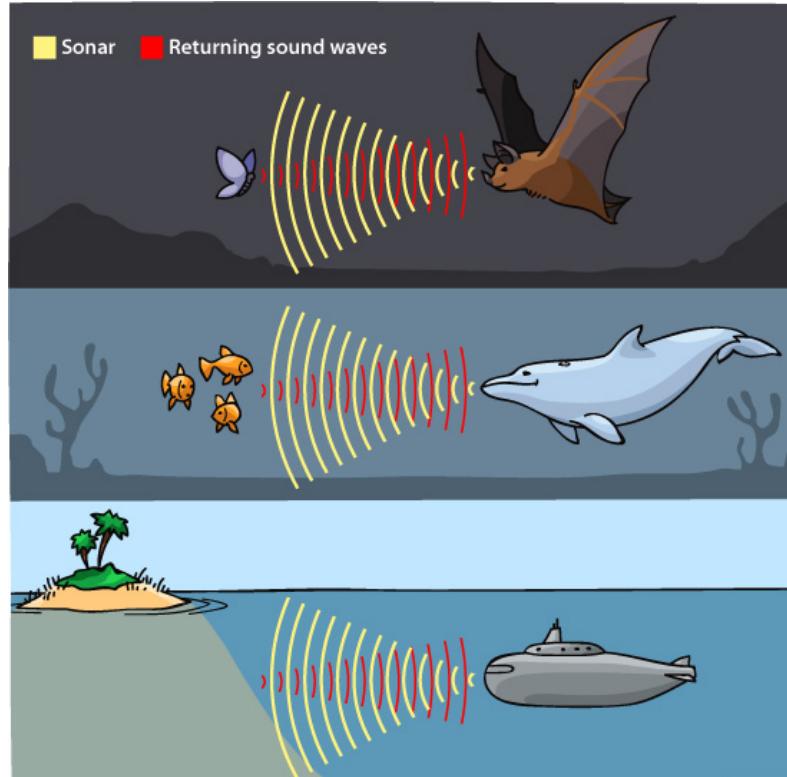
- Active sensors
- Have surface texture data
- See through weather and clouds
- Different wavelengths - different applications

Band	Frequency	Wavelength	Typical Application
Ka	27–40 GHz	1.1–0.8 cm	Rarely used for SAR (airport surveillance)
K	18–27 GHz	1.7–1.1 cm	rarely used (H_2O absorption)
Ku	12–18 GHz	2.4–1.7 cm	rarely used for SAR (satellite altimetry)
X	8–12 GHz	3.8–2.4 cm	High resolution SAR (urban monitoring; ice and snow, little penetration into vegetation cover; fast coherence decay in vegetated areas)
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S	2–4 GHz	15–7.5 cm	Little but increasing use for SAR-based Earth observation; agriculture monitoring (NISAR will carry an S-band channel); expands C-band applications to higher vegetation density)
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P	0.3–1 GHz	100–30 cm	Biomass. First p-band spaceborne SAR will be launched ~2020; vegetation mapping and assessment. Experimental SAR.



What is Synthetic Aperture Radar?. Source:[NASA Earth Data](#)

Comparisons



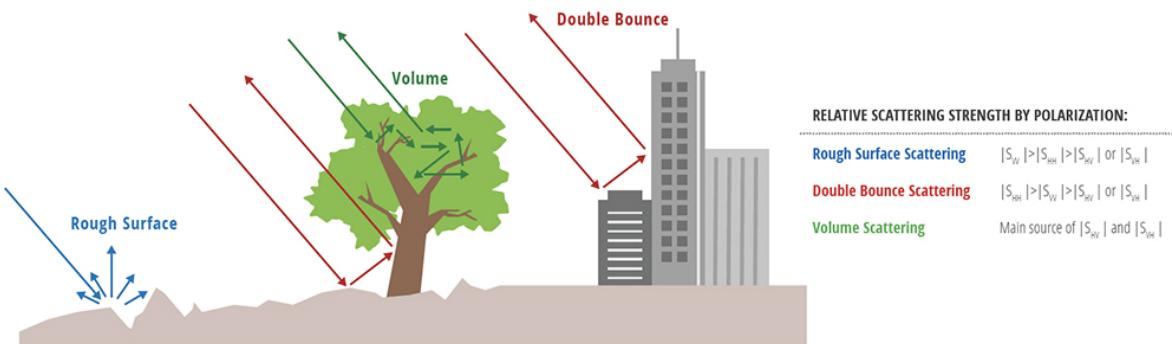
Sound waves and sound reflection is used by bats and dolphins to echolocate; this process was studied and used to improve underwater sonar that we use in submarines and other water vessels. Source:[askabiologistasu](#)

- Ripple tank simulator

SAR background 2

- Also different polarizations - orientation of the plane in which EMR waves transmitted..

Polarization refers to the orientation of the plane in which the transmitted electromagnetic wave oscillates. While the orientation can occur at any angle, SAR sensors typically transmit linearly polarized. The horizontal polarization is indicated by the letter H, and the vertical polarization is indicated by V.

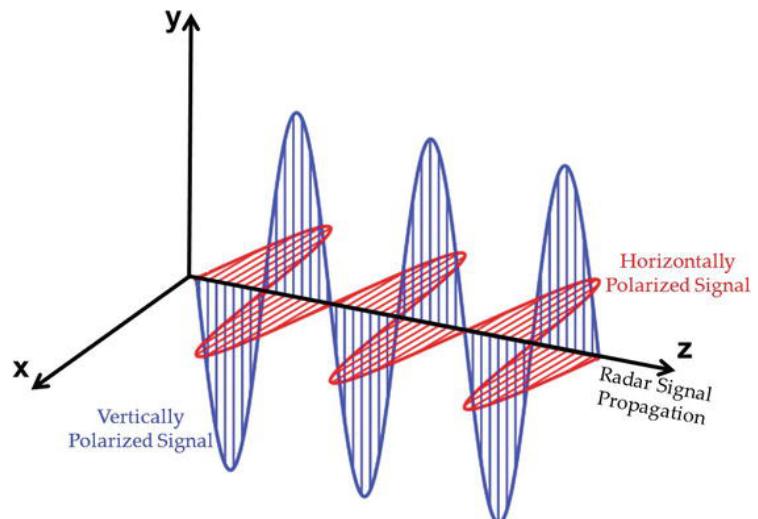


What is Synthetic Aperture Radar?. Source:[NASA Earth Data](#)



SAR polarization

- Also different polarizations:
 - orientation of the plane in which EMR waves transmitted..
 - "direction of travel of an electromagnetic wave vector's tip: vertical (up and down), horizontal (left to right), or circular (rotating in a constant plane left or right)."'
- Single = 1 horizontal (or vertical)
- Dual = transmits and receives both horizontal and vertical
- HH = emitted in horizontal (H) and received in horizontal (H)



Polarization. Source: [Wetland Monitoring and Mapping Using Synthetic Aperture Radar](#)

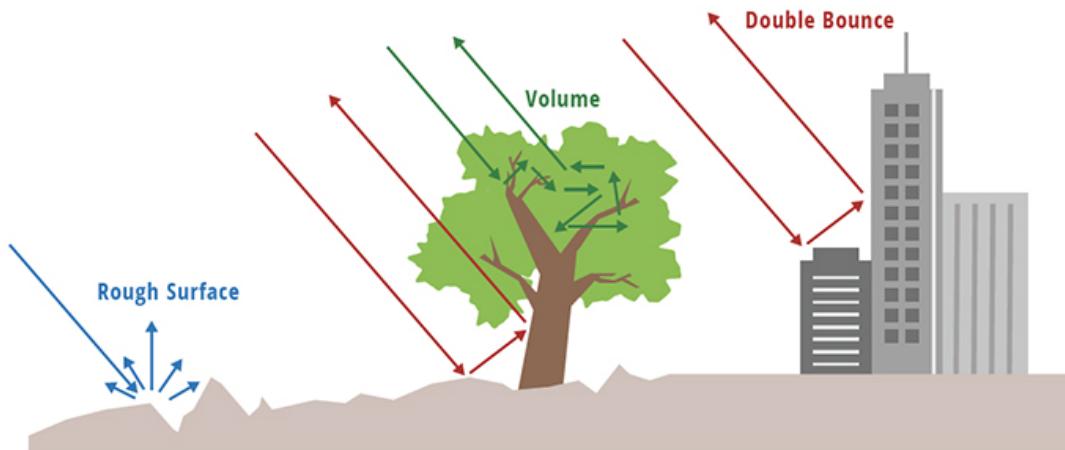
- Can change when interacting with materials



SAR polarization

Different surfaces respond differently to the polarizations

- Rough scattering (e.g. bare earth) = most sensitive to VV
- Volume scattering (e.g. leaves) = cross, VH or HV
- Double bounce (e.g. trees / buildings) = most sensitive to HH.



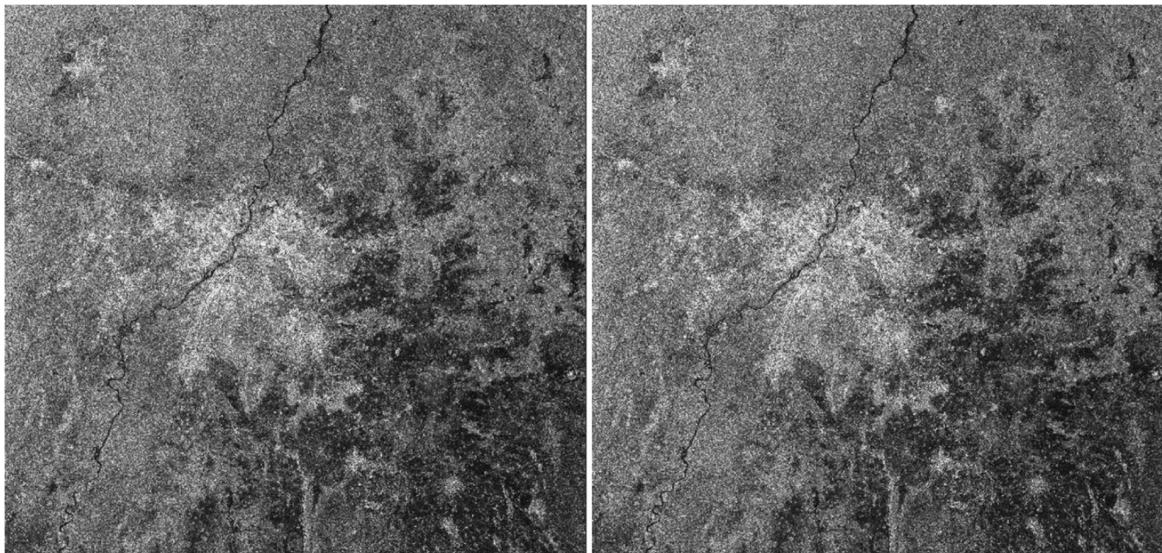
RELATIVE SCATTERING STRENGTH BY POLARIZATION:

Rough Surface Scattering	$ S_{VV} > S_{HH} > S_{VH} $ or $ S_{HV} $
Double Bounce Scattering	$ S_{HH} > S_{VV} > S_{VH} $ or $ S_{HV} $
Volume Scattering	Main source of $ S_{VH} $ and $ S_{HV} $

What is Synthetic Aperture Radar?. Source:[NASA Earth Data](#)



SAR image



(a) *Image before orbit file update operation*

(b) *Image after orbit file update operation*

Paper also goes through some correction methods that should be familiar!

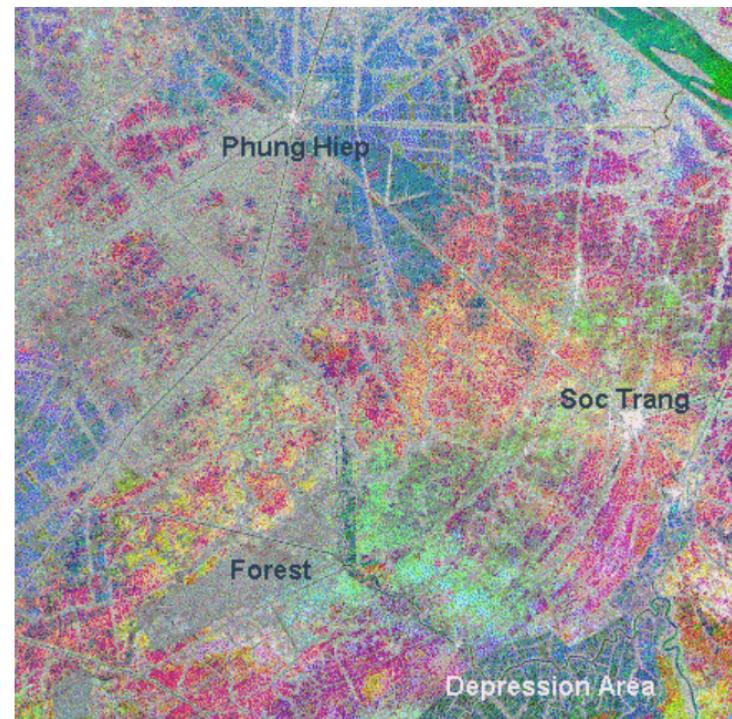
Urban objects detection from C-band synthetic aperture radar (SAR) satellite images through simulating filter properties. Source:[Deepak Kumar, 2021](#)



SAR image 2

"multitemporal colour composite SAR image, rice growing areas in the Mekong River delta, Vietnam 1996."

"Three SAR images acquired by the ERS satellite during 5 May, 9 June and 14 July in 1996 are assigned to the red, green and blue channels respectively for display. The colourful areas are the rice growing areas, where the landcovers change rapidly during the rice season. The greyish linear features are the more permanent trees lining the canals. The grey patch near the bottom of the image is wetland forest. The two towns appear as bright white spots in this image. An area of depression flooded with water during this season is visible as a dark region."

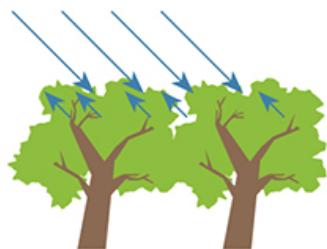


SAR Images. Source:[CRISP](#)

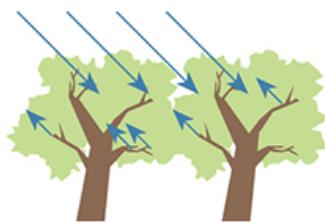
SAR background 3

Scattering can change based on wavelength

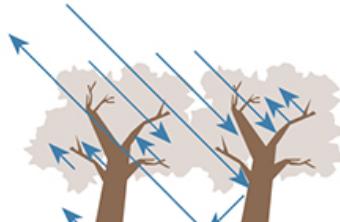
Further penetration then the volume scattering will change



X-BAND 3 cm



C-BAND 6 cm



L-BAND 24 cm



P-BAND 65 cm

What is Synthetic Aperture Radar?. Source:[NASA Earth Data](#)



SAR background 4

Some terms:

Backscatter is the portion of the outgoing radar signal that the target redirects directly back towards the radar antenna

The higher the backscattered intensity = rougher the surface. It is "unitless"

Can be converted to "backscatter coefficient, or sigma nought", measured in decibel (dB) units = normalised measure of the radar return from a distributed target

If the signal is from backscatter is not desired = "clutter"

- Has been used in urban monitoring BUT...
 - Corner reflections in urban environments
 - Shadowing - building behind another not imaged
 - Speckle - grainy, from scattering on ground - "salt and pepper"

Source:[NASA Earth Data](#)

Source:[Urban Area Delineation Using InSAR Products](#)

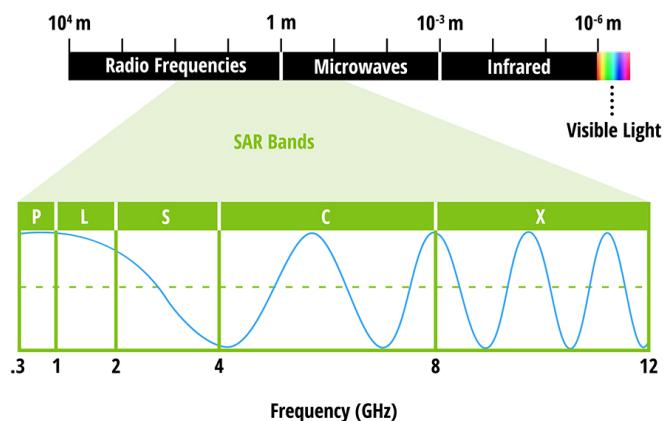


SAR background

- Wavelength of SAR can change application

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- Remember this is on the electromagnetic spectrum (EMR)



What is Synthetic Aperture Radar?. Source:[NASA Earth Data](#)

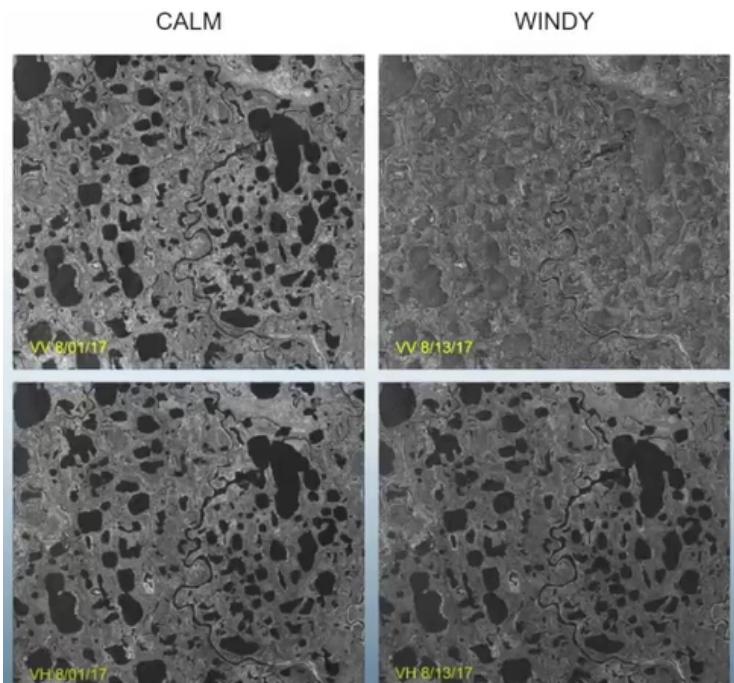


Amplitude (backscatter) and phase

A SAR signal has both **amplitude** (backscatter) and **phase** data

Backscatter (amplitude)

- Polarization
 - VV = surface roughness
 - VH = volume of surface (e.g. vegetation has a complex volume and can change the polarization)
- Permittivity (dielectric constant) - how **reflective** is the property which means **reflective back to the sensor**. Water usually reflects it off elsewhere
- The return **value**, also remember the band (wavelength)



Images: ASF DAAC 2019 using GAMMA software. Contains modified Copernicus Sentinel data 2017, processed by ESA

- Wind makes the water move and reflect back to the sensor (under VV)

NASA Data Made Easy: Part 2- Introduction to SAR. Source:[NASA Earth Data](#)

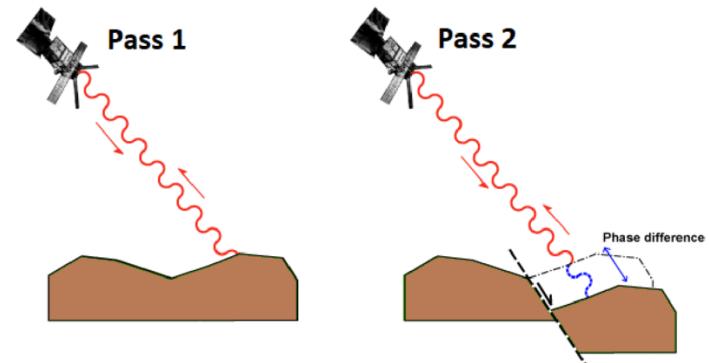


Amplitude (backscatter) and phase

A SAR signal has both **amplitude** (backscatter) and **phase** data

Phase

- Location of wave on the cycle when it comes back to the sensor



InSAR. Source:[Pascal Castellazzi](#)



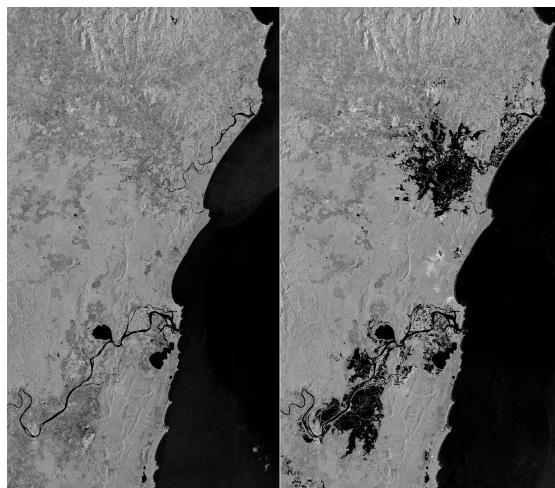
SAR floods

Sensor

- Sentinel-1 SAR

ENSO phases but this is from Australian La Niña 2022

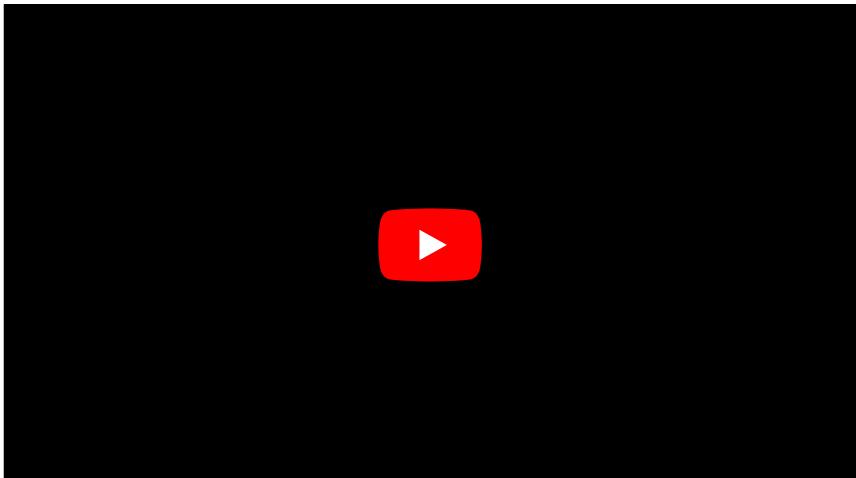
- trade winds from south america intensity
- draw up cool deep waters and increase thermocline
- temp difference increases, walker circulation intensifies - feedback loop
- more cloud + more rain + cyclones in West Pacific



Eastern Australia Floods. Source:[brockmann-consult](#)

ENSO

El Niño–Southern Oscillation (ENSO)



Me on SAR

Although SAR images over urban areas provide low quality images due to problems associated with radar imaging in such an environment (i.e. multiple bouncing, layover and shadowing), SAR texture measures can provide valuable information in discerning urban areas (Dell'Acqua et al., 2003; Zhu et al., 2012). Isolated scattering of residential areas and crowded backscatters of inner city high density areas permit classification refinement, thus textural measures such as those described within the spatial domain can aid identification of alternative urban forms (Zhu et al., 2012).

However, the lack of freely available SAR data that temporally coincides with other satellite imagery (e.g. Landsat) frequently precludes extensive use



To use SAR or not to use SAR...that is the question...



InSAR

Interferometry Synthetic Aperture Radar (InSAR)

- Take two RADAR observations of the target (e.g. the ground)
- Use the phase difference
- Phase =

"total number of cycles of the wave at any given distance from the transmitter, including the fractional part"

- Phase difference - SUBTRACT the values (measured phase values) at two different measurement points
- Differential distance depends on the height of the terrain (topography)
- Used for creating DEMs
- Monitoring displacement of ground - earthquakes etc

INTERFEROMETRY EXPLAINED - MORE DETAIL. Source:[NASA SRTM](#)



InSAR 2

Key terms

- Coherence Map

Coherence is defined as the degree of similarity of backscattering response (or reflection characteristic of as measured by the SAR sensor) between corresponding ground cells in both SAR image of an InSAR pair.

Something is coherent when they are in phase (vibrate in unison)

- Differential Interferometry Synthetic Aperture Radar (DInSAR) - more on this later

"quantification of the ground displacement that occurred between the two acquisitions can be achieved" through a "differential interferogram"

Source:[Michel Gay](#)



SAR applications

SAR applications, an emerging trend: https://www.mdpi.com/journal/remotesensing/special_issues/Urban_SAR

- Damage detection
- Urban area mapping
- Urban flooding (lower backscatter coefficient)
- Landslides
- Earthquakes
- Data fusion* / DEM creation



Monitoring forests + illegal logging

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* 342, 850–853.

Sensor

- Landsat (2000 to 2012)

Monitoring forest loss and illegal logging

- Pre-processing

"Landsat pre-processing steps included: (i) image resampling, (ii) conversion of raw digital values (DN) to top of atmosphere (TOA) reflectance, (iii) cloud/shadow/water screening and quality assessment (QA), and (iv) image normalization"

The stack of QA layers was used to create a perpixel set of cloud-free image observations which in turn was employed to calculate timeseries spectral metrics.



Monitoring forests + illegal logging 2

- Creating metrics

Metrics represent a generic feature space that facilitates regional scale mapping and have been used extensively with MODIS and AVHRR data

(i) reflectance values representing maximum, minimum and selected percentile values (ii) mean reflectance values for observations between selected percentiles (iii) slope of linear regression of band reflectance value versus image date.

In support of this reference is given to [Hansen et al. 2010](#)...supplementary material...

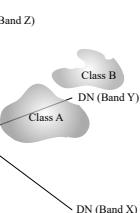
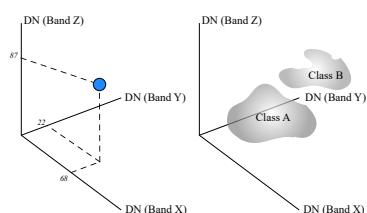
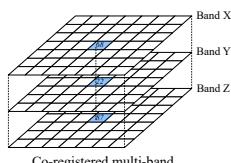
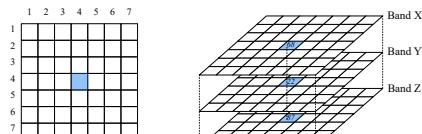
The time-sequential MODIS 32-day inputs were transformed to annual metrics to produce a more generalized feature space



Monitoring forests + illegal logging 3

"a more generalized feature space"

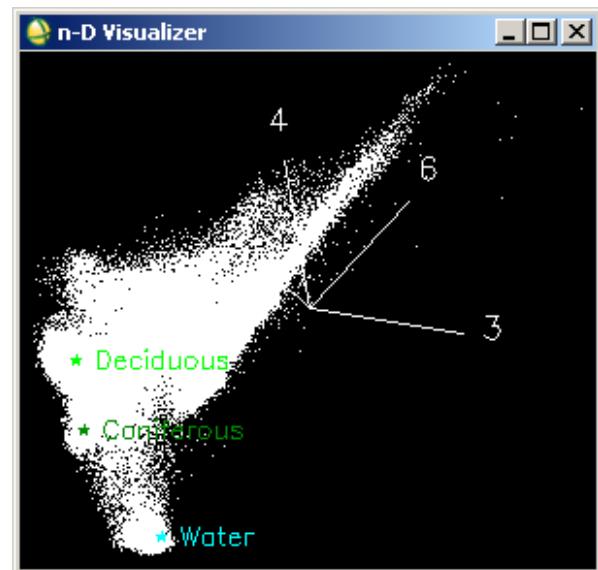
- Feature space = scattergram of two bands (or things that have been made into bands)
- Can be used for very basic classification - selecting the values that represent land cover



This work is licensed under a Creative Commons Attribution 3.0 Unported License.

Author: <http://commons.wikimedia.org/wiki/User:Arbeck>

Feature space. Source:Wikimedia commons 2022

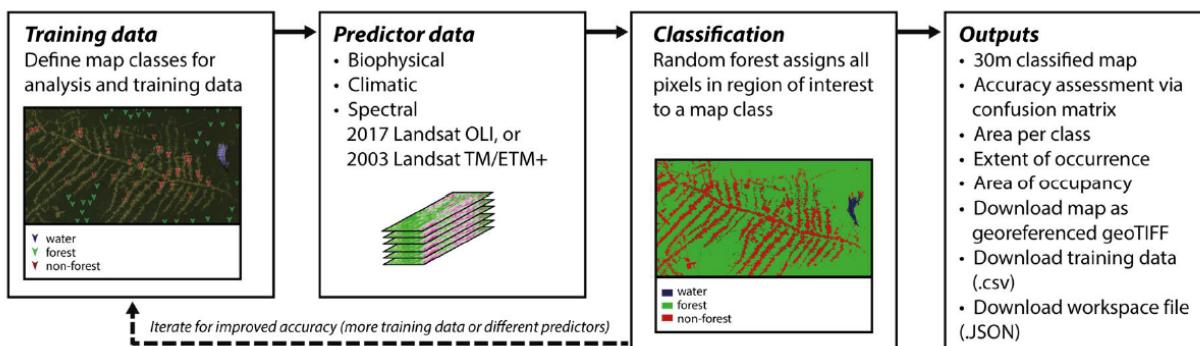


Spectral curves on the scatter plot. Source:50northspatial

Monitoring forests + illegal logging 4

- Training data (in supervised machine learning)

Training data to relate to the Landsat metrics were derived from image interpretation methods, including mapping of crown/no crown categories using very high spatial resolution data such as Quickbird imagery, existing percent tree cover layers derived from Landsat data (29), and global MODIS percent tree cover (30), rescaled using the higher spatial resolution percent tree cover data sets



REMAP method. Source:[UN-SPIDER](#)



Monitoring forests + illegal logging 5

- Classification (supervised or unsupervised)

Decision trees are hierarchical classifiers (top down) that predict class membership by recursively partitioning (splitting) a data set into more homogeneous or less varying subsets, referred to as nodes

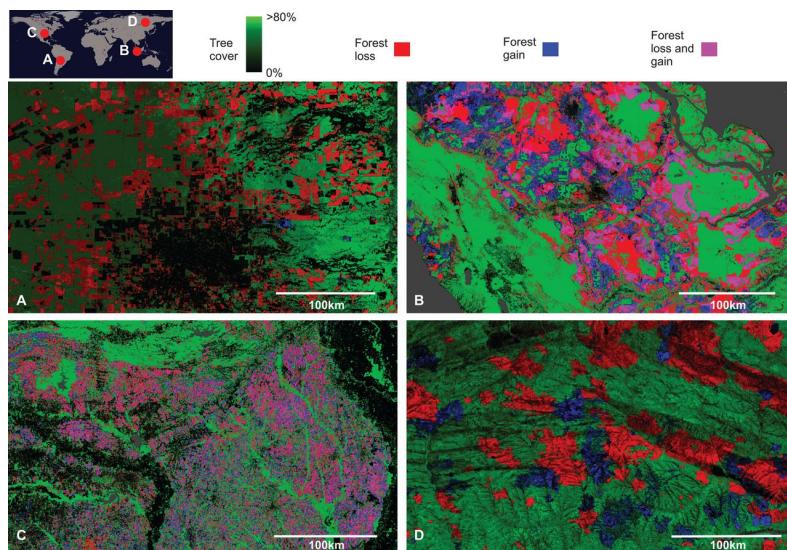


 FIG. 2 Regional subsets of 2000 tree cover and 2000 to 2012 forest loss and gain.(A) Paraguay, centered at 21.9°S, 59.8°W; (B) Indonesia, centered at 0.4°S, 101.5°E; (C) the United States, centered at 33.8°N, 93.3°W; and (D) Russia, centered at 62.1°N, 123.4°E. Source:[Hansen et al. 2013](#)

Used in Brazil to target illegal logging

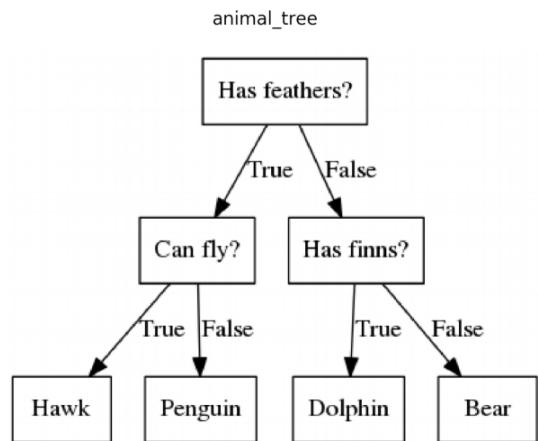
Monitoring forests + illegal logging 6

Decision trees are hierarchical classifiers that predict class membership by recursively partitioning a data set into more homogeneous or less varying subsets, referred to as nodes

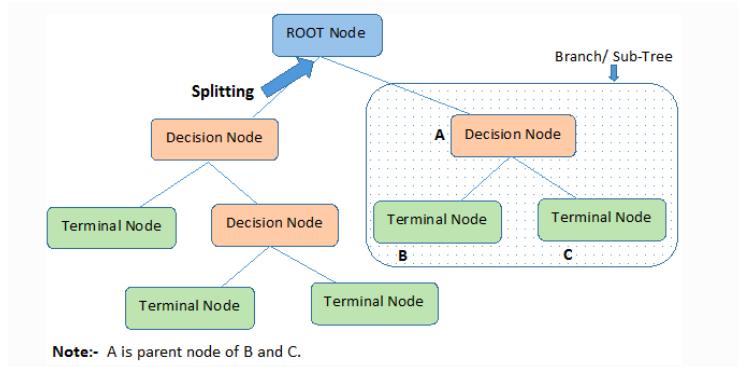
- A random forest classifier is a collection of decision trees
- Take something complex and force into many decisions = if-else conditions or also called divide and conquer.
- Often requires hyperparameters to train the model (or control the learning process) - e.g. the choices we've made in the past...sort of...
 - DBSCAN (radius of points, Epsilon or MinPts - to make a cluster)
 - Spatial weight matrix (type and then weight)
- Split the data into more and more homogeneous subsets (filtering!) this can be limited through
 - pre-pruning - set a number of iterations before
 - post-pruning - reduce groups afterwards based on accuracy. Tree fully grows but will be overfit.



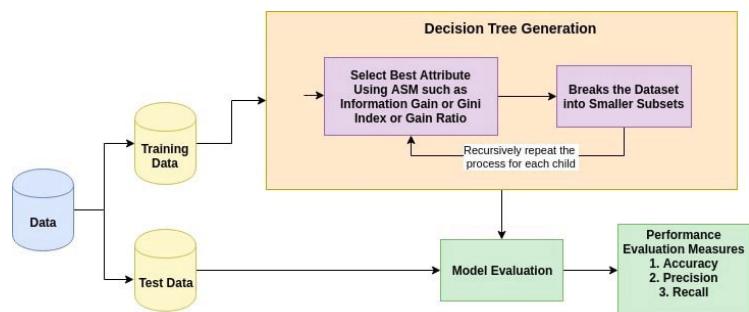
Decision trees..briefly



Decision tree. Source:[towardsai](#)



Decision tree. Source:[towardsai](#)



Decision tree. Source:[towardsai](#)

Decision trees..briefly 2

Post pruning

In post-pruning first, it goes deeper and deeper in the tree to build a complete tree. If the tree shows the overfitting problem then pruning is done as a post-pruning step. We use a cross-validation data to check the effect of our pruning. **Using cross-validation data, it tests whether expanding a node will make an improvement or not.** If it shows an improvement, then we can continue by expanding that node. But if it shows a reduction in accuracy then it should not be expanded i.e, the node should be converted to a leaf node.

tidymodels

In R we have the new `parsnip` package... it let's us change models without changing the data / packages...

Type = random forest, decision trees etc **mode** = classification or regression **engine** Specific package or model fit...



Decision trees..briefly 3

- Prepare the model and testing / training

```
library(tidymodels)
tidymodels_prefer()
data(Chicago)

n <- nrow(Chicago)
Chicago <- Chicago %>% select(ridership, Clark_Lake, Quincy_Wells)

Chicago_train <- Chicago[1:(n - 7), ]
Chicago_test <- Chicago[(n - 6):n, ]

dt_reg_spec <-
  decision_tree(tree_depth = 30) %>%
  # This model can be used for classification or regression, so set mode
  set_mode("regression") %>%
  set_engine("rpart")
dt_reg_spec
```



Decision trees..briefly 4

- Fit the train data to the tree
- Test it with the testing data

```
set.seed(1)
dt_reg_fit <- dt_reg_spec %>% fit(ridership ~ ., data = Chicago_train)
dt_reg_fit

predict(dt_reg_fit, Chicago_test)
```



Droughts

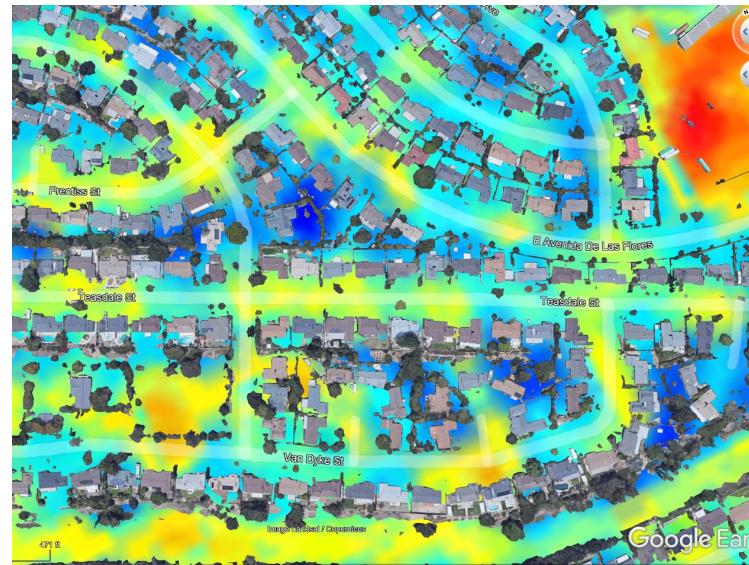
Who is still watering their garden in a drought?

- Southern California 2022 drought and water shortage - **cities of Conejo Valley** and Thousand Oaks
- Various **rules about watering for residential properties**
- Sentinel moisture index to spot who is watering too much?

This is...

$$NDMI = \frac{(B08-B11)}{(B08+B11)}$$

- How can the cities prevent this...



See the Twitter thread for other examples. Source:@ai6yrham



Forest fires

- Dates back to the most cited paper on the topic
 - "Application of remote sensing and geographic information systems to forest fire hazard mapping", Chuvieco and Congalton 1989.

Used:

- Sensor Landsat TM 1984
- vegetation, elevation, slope, aspect and road/house proximity = fire hazard map compared to burned map from Landsat
- Did a weighted overlay of the layers - giving hazard value of 0 to 255, some layers had assigned values (e.g. aspect of 90-180 a value of 0)
- Vegetation was from a classified Landsat TM image - classified 16 categories
- No accuracy assessment
- I assume they manually delineated the burned area pixels

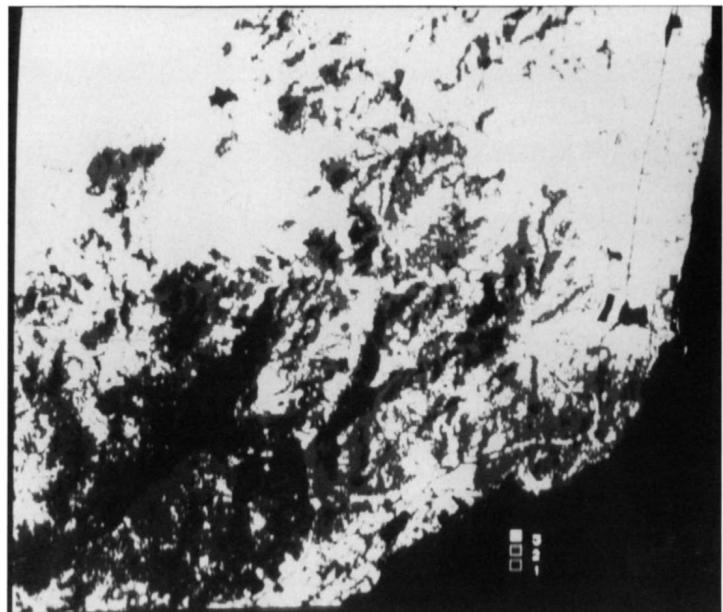


Figure 8. Hazard index map. For display purposes, the whole range of hazard index values has been divided in three categories: 1) high hazard (1–100); 2) medium hazard (101–200); 3) low hazard (201–255).

Source:Chuvieco and Congalton 1989



Forest fires 2

Whilst somewhat more complex with additional variables and analysis this approach is still being used...e.g.

9 parameters in creating a fire action plan for Ecuador...

Fire severity - **Landsat-8 OLI** 2014 and 2020

$$dNDVI = \text{pre}NDVI - \text{post}NDVI$$

$$dNBR = NBR_{\text{pre}} - NBR_{\text{post}} \text{ (similar to NDVI)}$$

Verified from field visits

Call this a severity model? but kept the indices separate

Used this to designate safe escape routes..

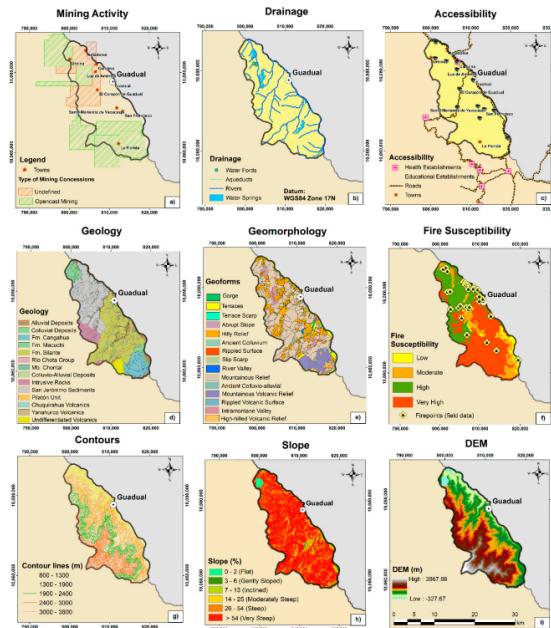


Figure 14. Main aspects considered for the proposal of the fire action plan. (a) Mining activity in the region, (b) drainage (water bodies), (c) accessibility (roads and health facilities), (d) geological formations, (e) representative geoforms, (f) fire susceptibility model and fire-starting points, (g) contour lines (elevation), (h) slope classifications, (i) digital elevation model (DEM) or altitude map. Source: adapted from [74–77,125].

Source: Morante-Carballo et al. 2022

Which variables used remote sensing?

Only the severity which wasn't even overlaid directly

The study was somewhat confusing with a focus on severity (the aim) which then changed to a fire action plan that didn't show severity as a factor

No method was given for the action plan development



Combining this into a model...

Modeling the relationships between historical redlining, urban heat, and heat-related emergency department visits: An examination of 11 Texas cities, Li et al. 2022

Data:

- Red lined districts .shp (more on this in future lecture)
- Social vulnerability factors from American community survey: population aged 65 and older, non-White population, Hispanic population, lower-income population, individuals living alone, and populations who do not speak English well.
 - Normalised by population
- Visit to emergency departments for heat related illness
- LST data from the ECO2LSTE product within the 1 June and 31 August 2018–2020 window
 - **One daytime and one nighttime imagery set** with best quality flags were selected for each city (Figure 2), and summary measures such as mean daytime/nighttime LST, minimum daytime/nighttime LST, and maximum daytime/nighttime LST were determined with reference to ZCTA boundaries



Not clear what a set is ?

A single image?



Combining this into a model...2

Methods:

- spatial autoregressive model (SAR) instead - Lag and error model
 - this means spatial regression!
 - recall from [CASA0005](#)
 - lag = include values of near by polygons
 - error = residuals of values in near polygons

Modelling:

- LST
- heat-related ED visits

Output:

- "these results suggest that inequalities in urban heat island conditions exist not only between the historically defined redlined and non-redlined zones but also between contemporary geographic units that contain more versus fewer historically redlined areas."



Refresher...

In what circumstance might we use a spatial regression model?

Where are residuals (errors) in linear regression are spatially autocorrelated (e.g. from Moran's I telling us how similar nearby objects are based on a weight matrix)



The key

- The key is *usually combining the remote sensing data* with GIS or other datasets to answer questions
- The remotely sensed data is consistent over days, months and years
- Often papers don't:
 - Link to population / people
 - Say how we can inform policy...

For example

- Where should initiatives be targeted for reducing air pollution
- What areas / population are most at risk from forest fires or where should remediation be targeted
- How can illegal monitoring be most effectively stopped



The key in detail..

Our findings suggest that these challenges are distributed unevenly, and that historically redlined neighborhoods bear a disproportionately heavy burden. Existing heat-hazard prevention and mitigation plans are mostly based on entire region or city-level conditions, while few policies and initiatives pay attention to the inequalities rooted in long-standing spatial patterns of disinvestment and segregation in cities. Understanding how disparities in heat-related health conditions may have emerged through historical housing segregation can focus attention and resources on redressing these structural inequalities

Questions / critical reflection:

- If i am a city planner how can we start to address this
- What areas should i start with (funding often limited)
- What stage in the planning process might this come
- Who would be responsible (e.g. what department)
- What skills do they need
- What benefits can this bring to the city (often finances!)
- How does this help the city align with global agendas
- What stakeholders do i need to consider



The key in detail..

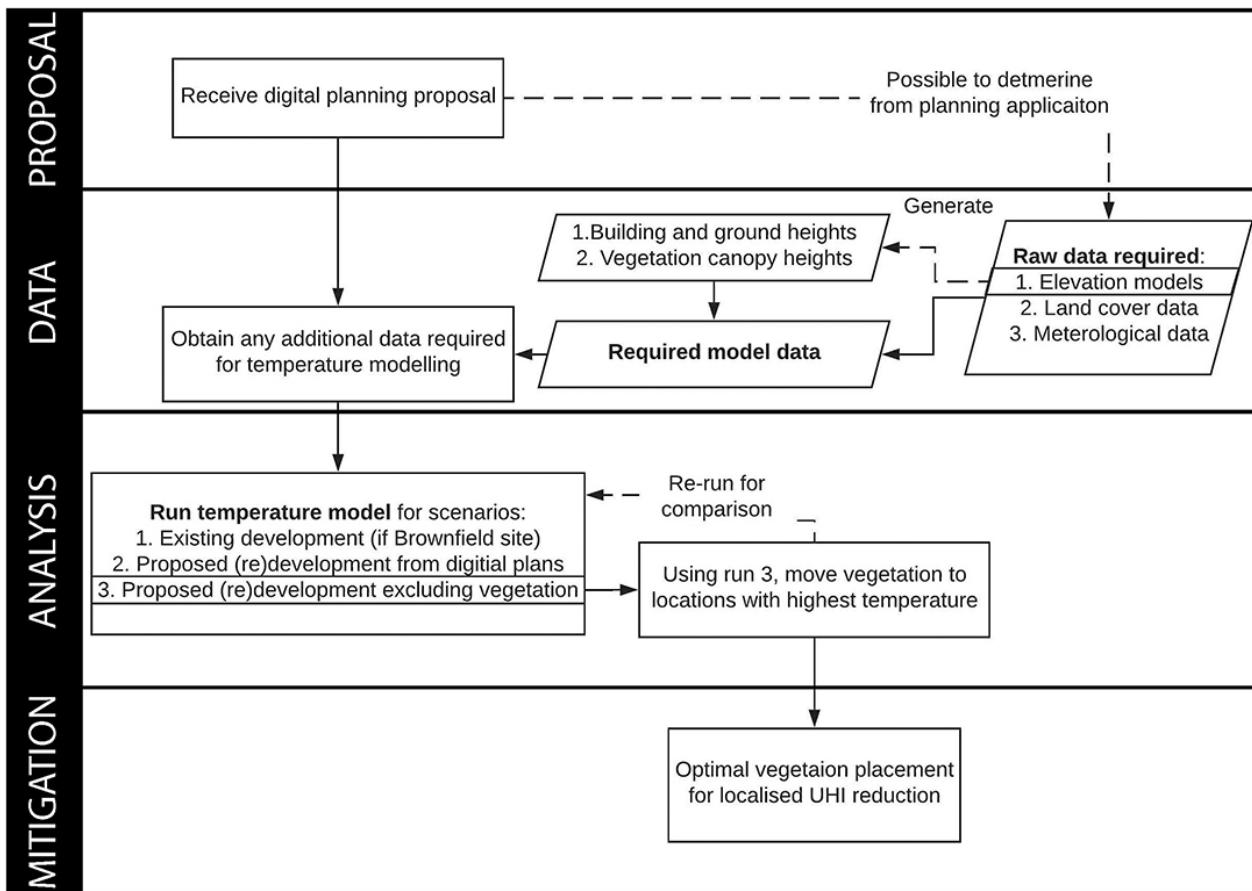
Often these considerations and questions are easily achievable from the data we have...

For example...

- The regression models will have produced Coefficient estimates
 - They represent a one unit change in the independent represents a drop or rise in dependent (note this study didn't show this)
 - In spatial regression we can also compute direct and indirect effects due to the lag
 - We will have the spatial data for these variables....that we can map ...
- We also have the Coefficient t-value:
 - greater the relative effect that particular independent variable is having on the dependent variable



Example of integrating analysis...



Source: MacLachlan et al. 2021

We will explore methods in the next few weeks
But first we will explore policy to understand where remote sensing data
can be applied.



Global policy documents

- New Urban Agenda = standards and principles for planning, construction, development, management and urban improvement

An example of commitments... Environmentally sustainable and resilient urban development subsection

point 64

point 65

point 67

We also recognize that urban centres worldwide, especially in developing countries, often have characteristics that make them and their inhabitants especially vulnerable to the adverse impacts of climate change and other natural and human-made hazards,

including earthquakes, extreme weather events, flooding, subsidence, storms, including dust and sand storms, heatwaves, water scarcity, droughts, water and air pollution, vector-borne diseases and sea level rise,

which particularly affect coastal areas, delta regions and small island developing States, among others.



Global policy documents

- New Urban Agenda = standards and principles for planning, construction, development, management and urban improvement

An example of commitments... Environmentally sustainable and resilient urban development subsection

point 64

point 65

point 67

We commit ourselves to facilitating the

sustainable management of natural resources in cities and human settlements in a manner that protects and improves the urban ecosystem and environmental services, reduces greenhouse gas emissions and air pollution and promotes disaster risk reduction and management,

by supporting the development of disaster risk reduction strategies and periodical assessments of disaster risk caused by natural and human-made hazards, including standards for risk levels..



Global policy documents

- New Urban Agenda = standards and principles for planning, construction, development, management and urban improvement

An example of commitments... Environmentally sustainable and resilient urban development subsection

point 64

point 65

point 67

We commit ourselves to promoting the creation and maintenance of well-connected and well distributed networks of

open, multipurpose, safe, inclusive, accessible, green and quality public spaces, to improving the resilience of cities to disasters and climate change, including floods, drought risks and heat waves

to improving food security and nutrition, physical and mental health, and household and ambient air quality, to reducing noise and promoting attractive and liveable cities, human settlements and urban landscapes and to prioritizing the conservation of endemic species.



Global policy documents

- Sustainable Development Goals (SDG) = targets with measurable indicators for monitoring
- Full indicators and notes on [SDG indicators](#)

Goal 11

Target 11.5

Monitoring 11.5

Data 11.5

- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable



Global policy documents

- Sustainable Development Goals (SDG) = targets with measurable indicators for monitoring
- Full indicators and notes on [SDG indicators](#)

Goal 11

Target 11.5

Monitoring 11.5

Data 11.5

- Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations



Global policy documents

- Sustainable Development Goals (SDG) = targets with measurable indicators for monitoring
- Full indicators and notes on [SDG indicators](#)

Goal 11

Target 11.5

Monitoring 11.5

Data 11.5

- 11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
- 11.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)
- 11.5.3 (a) Damage to critical infrastructure and (b) number of disruptions to basic services, attributed to disasters



Global policy documents

- Sustainable Development Goals (SDG) = targets with measurable indicators for monitoring
- Full indicators and notes on [SDG indicators](#)

Goal 11 Target 11.5 Monitoring 11.5

Data 11.5

- 11.5.1 (and .2) Data provider at national level is appointed Sendai Framework Focal Points. In most countries disaster data are collected by line ministries and national disaster loss databases are established and managed by special purpose agencies including national disaster management agencies, civil protection agencies, and meteorological agencies. The Sendai Framework Focal Points in each country are responsible of data reporting through the Sendai Framework Monitoring System.
- 11.5.3 National disaster loss database, reported to UNISDR...**Not every country has a comparable national disaster loss database that is consistent with these guidelines** (although current coverage exceeds 89 countries). Therefore, by 2020, it is expected that all countries will build/adjust national disaster loss databases according to the recommendations and guidelines by the OEIWG.



Positives and negatives with this guidance?



Global policy documents

Some new additions that have included spatial data...e.g...

Target 11.7 Target 11.6 Reflections

By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

- Indicator 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

Satellite imagery (open sources), documentation outlining publicly owned land and community-based maps are the main sources of data.

But...EO is included...

High resolution satellite imagery or Google Earth imagery can be used in this analysis. Open data sources such as OpenStreetMap (OSM) have some polygon data on open spaces in many cities



Global policy documents

Some new additions that have included spatial data...e.g...

Target 11.7

Target 11.6

Reflections

By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

- Indicator 11.6.2: Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
 - Sources of data include ground measurements from monitoring networks, collected for 3,000 cities and localities (WHO 2016) around the world, satellite remote sensing, population estimates...
estimated with improved modelling using data integration from satellite remote sensing, population estimates, topography and ground measurements (WHO, 2016a; Shaddick et al, 2016)
- The paper by Shaddick is hard to follow with no code.



Global policy documents

Some new additions that have included spatial data...e.g...

Target 11.7

Target 11.6

Reflections

These are two examples but comment on the complexity of the approaches..

- Who are they targeted at, what end user
- Who could replicate them
- Are they useful - how could the results be used



Metropolitan policy documents

Under the theme of disaster (flooding, landslides, drought, heatwaves etc)

London

OneNYC 2050

OneNYC 2050 2

Cape Town

Ahmedabad

Increasing efficiency and resilience

- These environmental threats are real and present, and London must be prepared for them. London's homes and infrastructure must be protected against the increasing likelihood of heatwaves, and developments must plan for a more integrated approach to water management, while minimising flood risk.

Policy SI 12 Flood risk management

- Development Plans should use the Mayor's Regional Flood Risk Appraisal and their Strategic Flood Risk Assessment as well as Local Flood Risk Management Strategies, where necessary, to identify areas where particular and cumulative flood risk issues exist and develop actions and policy approaches aimed at reducing these risks.



Metropolitan policy documents

Under the theme of disaster (flooding, landslides, drought, heatwaves etc)

London

OneNYC 2050

OneNYC 2050 2

Cape Town

Ahmedabad

- References the sustainable development goals
- Has a hazards matrix

NPCC projections on climate hazards and extreme events through the end of the century.
Source: NPCC

CHRONIC HAZARDS		BASELINE 1971–2000	2050 MIDDLE RANGE	HIGH END	MIDDLE RANGE	2100 HIGH END
AVERAGE TEMPERATURE		54°F	+4.1 TO 5.7°F	+6.6°F	+5.8 TO 10.4°F	+12.1°F
PRECIPITATION		50.1 IN.	+4 TO 11%	+13%	-1 TO +19%	+25%
		BASELINE 2000–2004	2050 MIDDLE RANGE	HIGH END	MIDDLE RANGE	2100 HIGH END
SEA LEVEL RISE		0	+11 TO 21 IN.	+30 IN.	+22 TO 50 IN.	+75 IN.
EXTREME EVENTS		BASELINE 1971–2000	2050 MIDDLE RANGE	HIGH END	MIDDLE RANGE	2100 HIGH END
HEAT WAVES & COLD EVENTS	NUMBER OF DAYS PER YEAR WITH AVERAGE TEMPERATURE AT OR ABOVE 90°F	18	39 TO 52	57	-	-
	NUMBER OF HEAT WAVES PER YEAR	2	5 TO 7	7	-	-
	AVERAGE DURATION IN DAYS	4	5 TO 6	6	-	-
	NUMBER OF DAYS PER YEAR WITH MINIMUM TEMPERATURE AT OR BELOW 32°F	71	42 TO 48	52	-	-
INTENSE PRECIPITATION	NUMBER OF DAYS PER YEAR WITH RAINFALL EXCEEDING 2 INCHES	3	4	5	-	-
		BASELINE 2000–2004	2050 MIDDLE RANGE	HIGH END	MIDDLE RANGE	2100 HIGH END
COASTAL FLOODS AT THE BATTERY	FUTURE ANNUAL FREQUENCY OF TODAY'S 100-YEAR FLOOD	1%	1.6 TO 2.4%	3.6%	-	-
	FLOOD HEIGHTS (FEET) ASSOCIATED WITH 100-YEAR FLOOD	11.3	12.2 TO 13.1	13.8	-	-

Middle range is 25th-75th percentile. High end is 90th percentile.



Source:[oneNYC](#)

Metropolitan policy documents

Under the theme of disaster (flooding, landslides, drought, heatwaves etc)

London

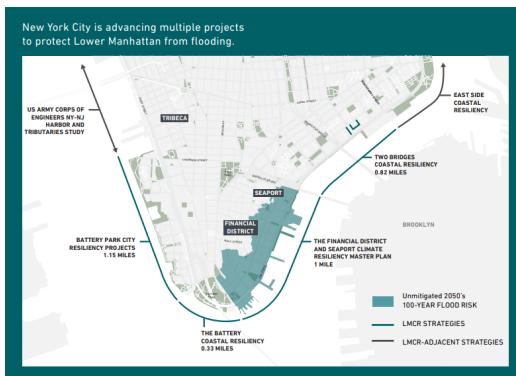
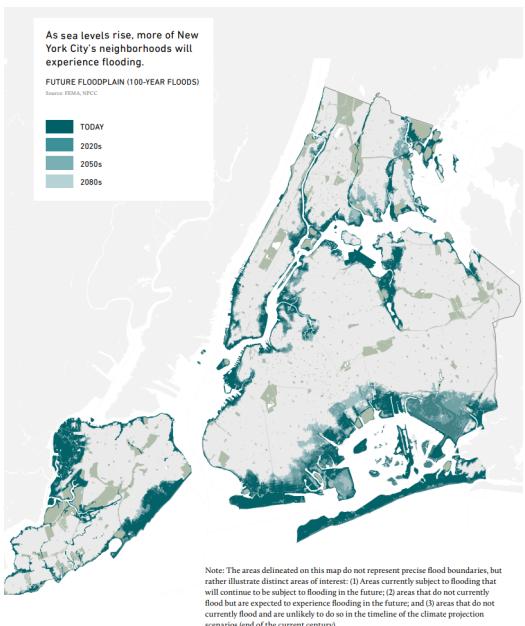
OneNYC 2050

OneNYC 2050 2

Cape Town

Ahmedabad

- Discusses coastal resiliency as an example of rising sea levels and flooding...BUT?..how do they do it?



Source:oneNYC

Metropolitan policy documents

Under the theme of disaster (flooding, landslides, drought, heatwaves etc)

London

OneNYC 2050

OneNYC 2050 2

Cape Town

Ahmedabad

[Cape Town Municipal Spatial Development Framework](#). Scroll to document downloads.

- 2015-2018 "worst recorded drought in the city's history, is a stark reminder that all cities will need to become more robust, resilient and efficient"
- "The Cape Town Spatial Development Framework (CTSDF) was approved in May 2012 and established a long-term spatial vision and policy framework for the City after extensive technical drafting and public participation."
- "Careful management of development to avoid developing in high flood risk areas"

States policies and their requirements ...BUT...HOW....

- Ollie and I wrote a [paper on Cape Town's response to COVID](#) that demonstrates the challenges within government.



Metropolitan policy documents

Under the theme of disaster (flooding, landslides, drought, heatwaves etc)

London

OneNYC 2050

OneNYC 2050 2

Cape Town

Ahmedabad

- 2010 severe heatwave leading to 1,344 additional deaths
- **2016 Heat Action Plan:**
 - Awareness and outreach
 - Early warning system
 - Capacity of health care professionals
 - Reduce heat exposure and promote adaptive measures ...and mapping high risk areas, although mapping was removed later in the document (page 11)
- Doesn't seem to appear in the publications, although spatial analysis is listed as a long term opportunity in the second paper:
 - Development and Implementation of South Asia's First Heat-Health Action Plan in Ahmedabad (Gujarat, India)
 - Rising Temperatures, Deadly Threat: Recommendations for Ahmedabad's Government Officials



Local policy documents

In most of the previous examples the documents were created by the metropolitan government:

- Greater London Authority
- Ahmedabad Municipal Corporation
- City of New York

Usually these are considered an upper tier

They set the strategic plan for the city and may have other responsibilities such as fire, policing, transport and development guidelines.

Lower tier government then carries out or adheres to these goals, for example....

- The Western Australian Planning Commission sets the statutory planning guidance that is carried out by local cities, such as the City of Perth and City of Fremantle.
- The Greater London Authority set the strategic goals for London with London Boroughs providing local services.



Local policy documents 2

BUT there are variations to this rule..

City of Cape Town New York

- The City of Cape Town is a metropolitan municipality or Category A municipality, there is no local municipality below it.
- However, **above** the City of Cape Town is the Provincial government that is responsible for topics such as: agriculture, education, health and public housing. As such the City sets its own development plan and then implements it (whilst adhering to relevant Provincial topics).



Local policy documents 2

BUT there are variations to this rule..

City of Cape Town

New York

- City of New York is responsible for public education, correctional institutions, public safety, recreational facilities, sanitation, water supply, and welfare services
- 5 Boroughs under it act as spokespeople
- City Council has 51 members from districts of about 157,000
- New York City is responsible for setting and enacting the policy. State government is above it.



Summary

- Wide variety of EO data that could be used
- Some studies fail to integrate their outputs with requirements of local areas, governments or cities with generic statements
- What use is it?
- Cities set policies but often focus on legislation or monitoring as opposed to prevention....
- How can we achieve their goals and improve urban areas more effectively in a data informed manner ?

