IDEAMAP SUDAN PUBLIC LECTURE

Geospatial Big Data and Cloud Computing

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Geospatial data is getting bigger and more difficult to analyse

- Satellites, drones, vehicles, social networks, mobile devices, cameras, etc. generate **vast amount** of (open) geospatial data.
- Numerous methods and (open-source) applications have been developed to enable **discovery, delivery, analysis, and visualization** of geospatial data.
- However, large and complex geospatial data sets are difficult to handle using **conventional systems and methods**.
- Data processing and analysis tasks are **time consuming**, sometimes even not possible, if they are performed on laptops or local workstations.

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Solutions require expert know-how and infrastructure

- Local and regional studies with medium size data

  Analyses can be done faster by **parallel computing** on a workstation

- Machine learning and AI studies with medium size data

  Analyses require **special processing units** (e.g., GPU/TPU) due to computational complexity

- National, continental, and global studies with big data

  Analyses require **distributed computing** on a computing cluster due to computational complexity and/or large volume of data

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Cloud computing is on-demand availability of computer system resources, especially **data storage** and **computing power**, without direct active management by the user

Computing is moving to the Cloud, so is geocomputing

- Developments in infrastructure, both hardware and software, gave a **big push** to data processing and analysis capabilities.
- **Scalable and affordable** computing is available through:
  - Open-source systems that allow computing clusters on commodity hardware
  - Proprietary cloud-based data storage and computing services
- However, it is **challenging to choose** the right solution(s) depending on the nature of geospatial data and analysis needs.
- Using the solutions usually requires a transition in **modus operandi**.

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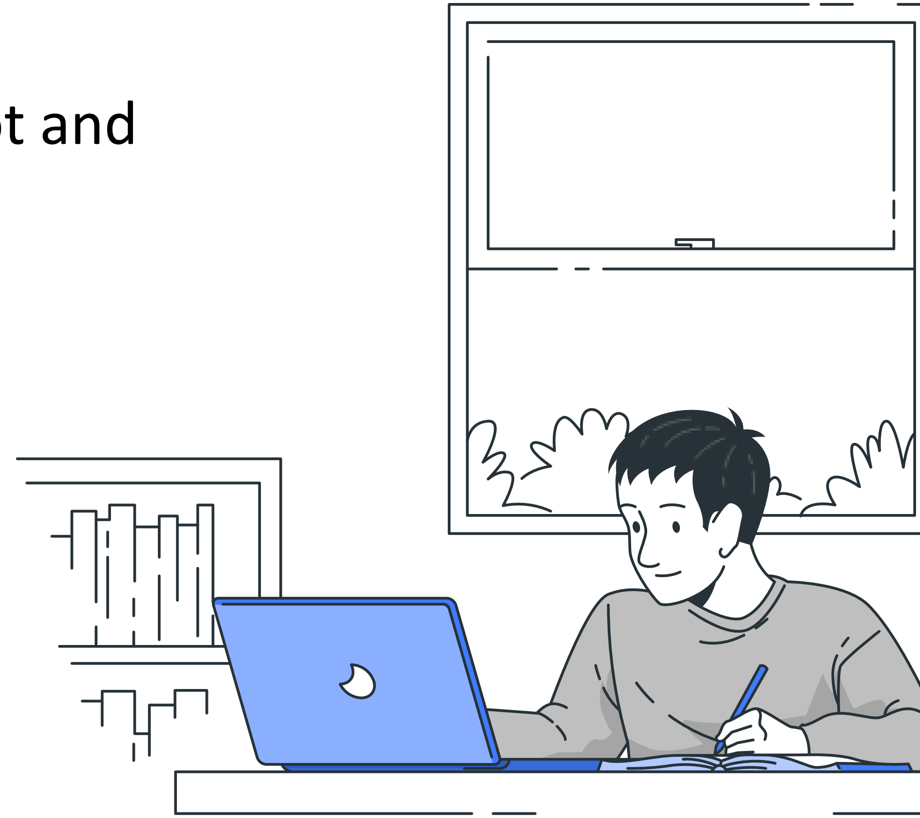
Not everyone requires cloud computing and big data, but…

- Institutions are usually **heterogeneous** with respect to interests and needs.
- For some people cloud computing and big data are not and probably will **not be relevant or interesting**.
- Even if there is no apparent need or interest, it is still important to have at least a **basic understanding** of these topics, because they are becoming **key components** in the geospatial domain.
- This should be an **institutional priority**.



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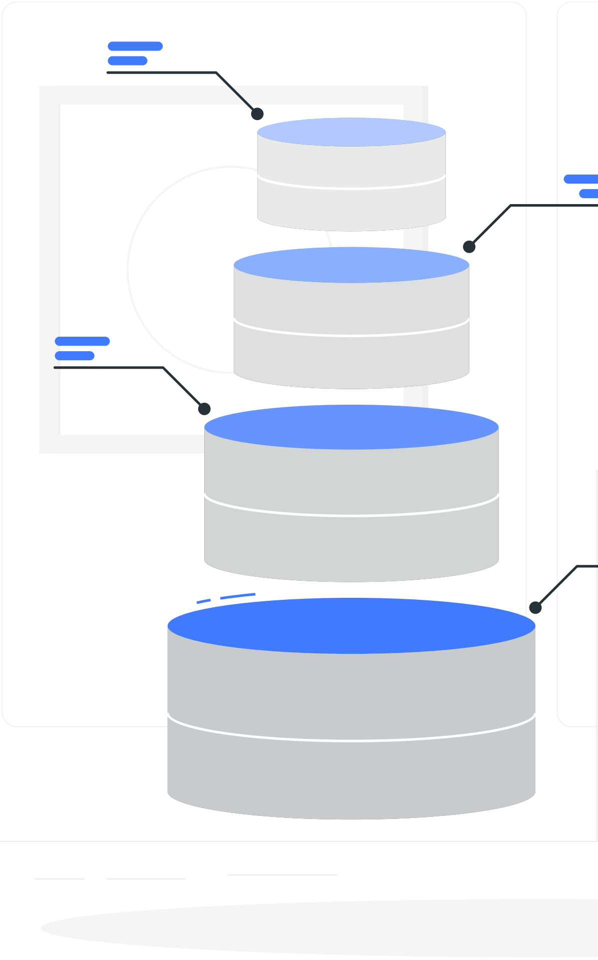
Cloud computing has a few distinctive features

- **On-demand self-service**: provision of computing capabilities as needed without requiring human interaction.
- **Broad network access**: availability over the Internet with standard access mechanisms for different client platforms (e.g., tablets, laptops, mobile phones).
- **Resource pooling**: dynamic assignment and reassignment of physical and virtual resources according to consumer demand.
- **Rapid elasticity**: capability to scale rapidly outward and inward proportionate to consumer demand.
- **Measured service**: accurate monitoring, control, and reporting of resource and service utilization.



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The features sound nice, but status quo is far from ideal

- Existing experience is **not widespread**, and difficulties exist in identifying the cases where cloud computing **can play a role**.
- Challenges exist in proper **selection and efficient use** of cloud computing methods, tools, and services.
- Available platforms and services are little used mainly due to **high cost** and limited **domain-specific technical support**.
- There is a high interest in **getting training** on how to (better) use cloud computing technology.
- There is also interest in **learning how** the technology is applied to solve domain-specific problems (e.g., what others do?)

Illustration by Storyset

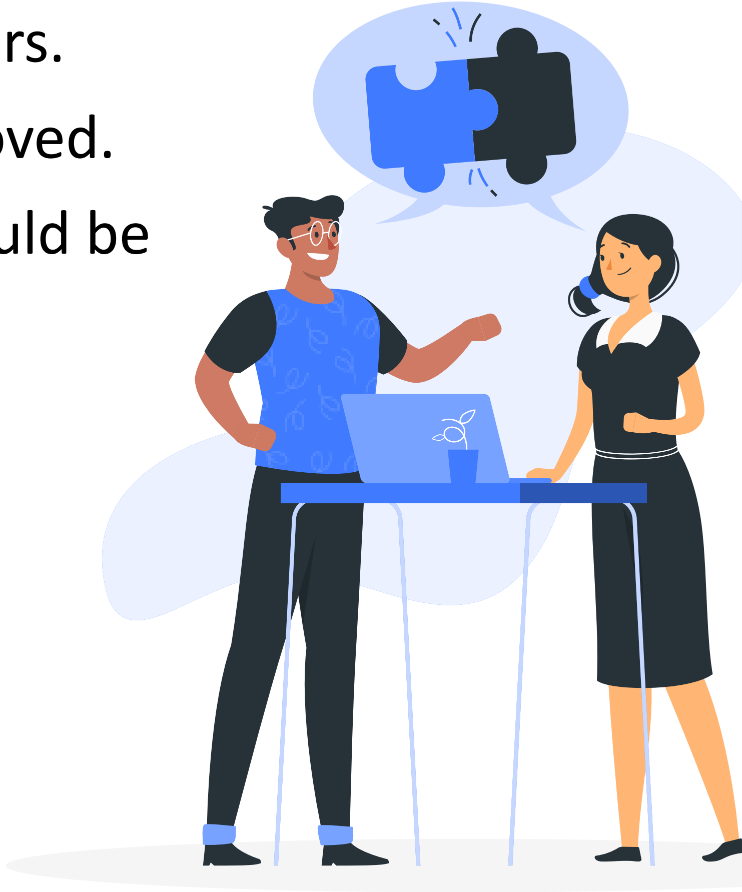
The landscape is large and complex

Source: https://mattturck.com/data2021/

Principal needs are usually similar for the different user groups

- State-of-the-art should be **actively communicated** to the users.
- **Proficiency** of the users on cloud computing should be improved.
- Easy-to-use and efficient cloud computing infrastructure should be **made available** for training and work purposes.
- Workflows should be **enhanced and improved** with cloud computing technology where relevant.
- Ad hoc technical **support and advise** should be provided.
- Knowledge and good practices on better use of technology should be **transferred** between partner institutions.

It is crucial to build a community that is self-motivated to learn, practice more, and share knowledge and experience!



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Rule One

Use the right tools!

Infrastructure as a Service (IaaS) – on demand virtual machines

- Provider supplies the infrastructure.
- User deploys and run arbitrary software, including operating system.
- Examples
  - Amazon AWS
  - Microsoft Azure
  - Google Cloud
  - ESA DIASs
  - National Research Clouds

Low level: Fine control on resources, custom system design, optimum performance, but difficult to manage, requires expertise!

Platform as a Service (PaaS)

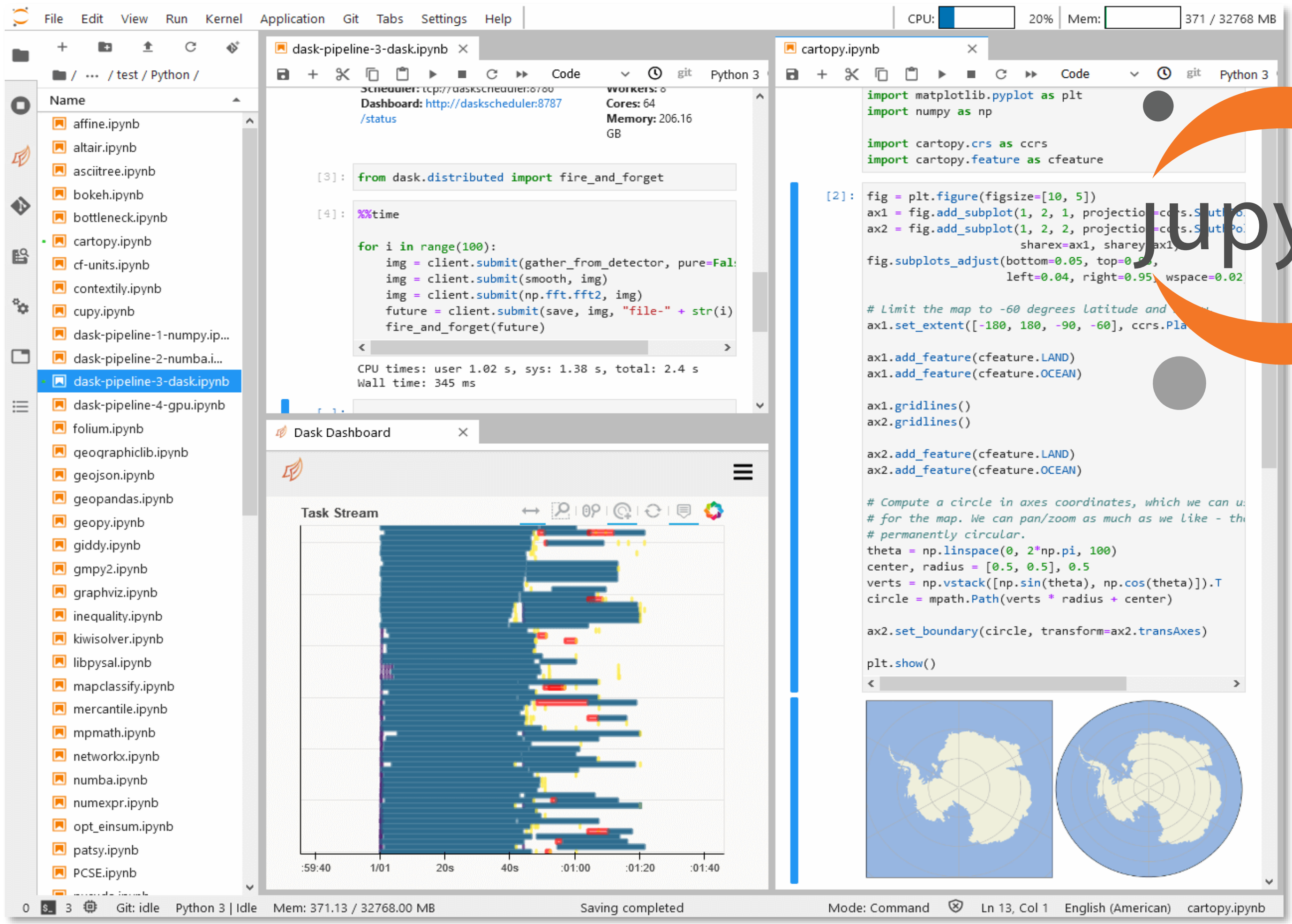
- Provider supplies the infrastructure, services, and tools that allow the user to deploy applications.
- User deploys applications and alters settings of the application hosting environment.
- Examples
  - Google Earth Engine
  - Microsoft Planetary Computer
  - ITC Geospatial Computing Platform
  - Google Colab
  - Amazon SageMaker

Medium level: Limited control on resources, custom workflow design, good performance, but requires programming skills!

Project Jupyter is a gamechanger for interactive computing

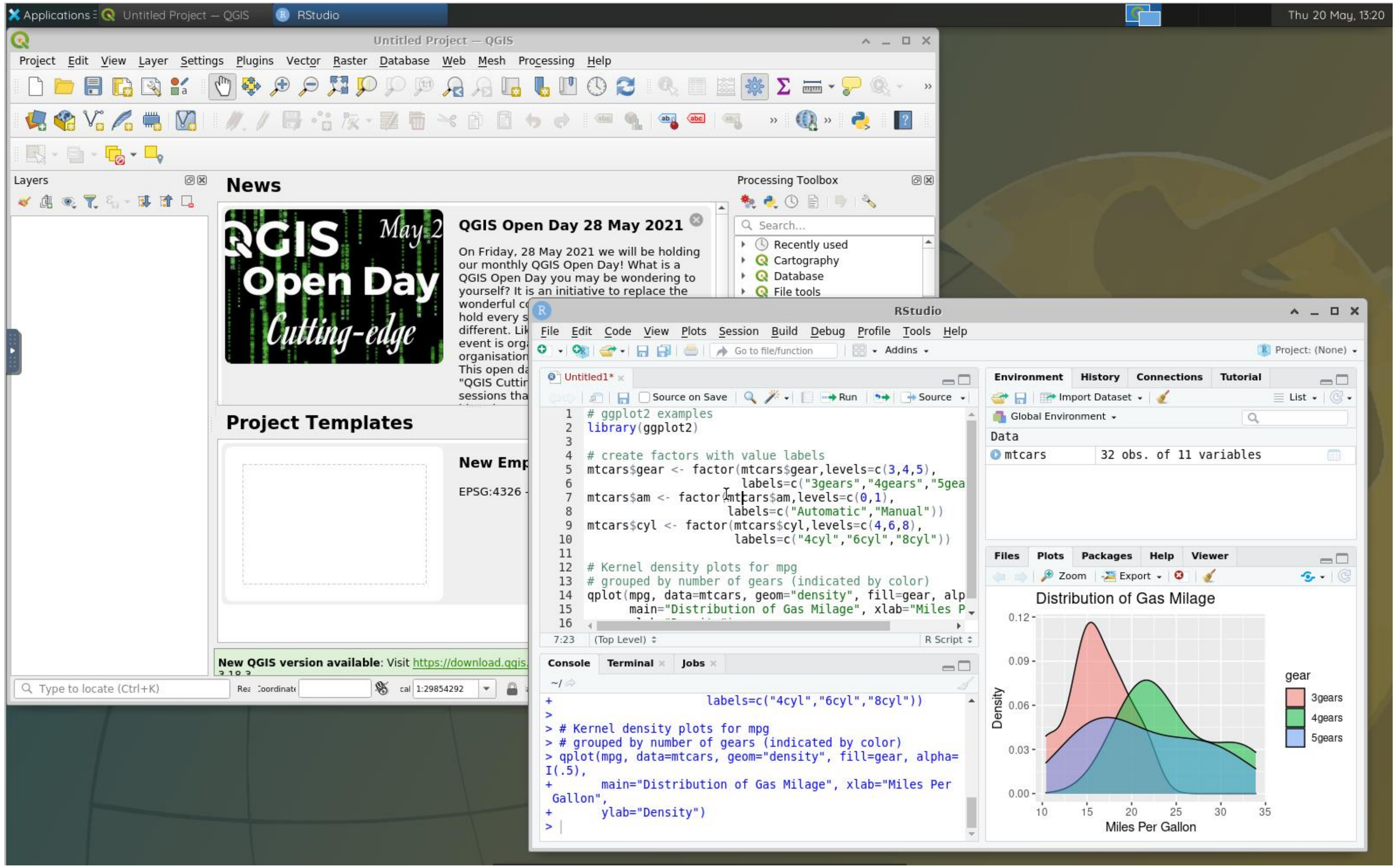
Free software, open standards, and web services for interactive computing across various programming languages

jupyter.org



jupyter

Remote desktop connection allows conventional access



Software as a Service (SaaS) – on demand application software

- Provider supplies the infrastructure that run the applications.
- User uses provided applications through an interface.
- Examples
  - ArcGIS Online
  - CartoDB
  - Mapbox
  - R Studio Cloud

High level: Easy to use, (usually) optimum performance, but no control on resources, usually paid!

There are also many other ..aaSs!

- Function as a service (**FaaS**)
- Data as a service (**DaaS**)
- Data Processing as a service (**DPaaS**)
- ...

There are also many cloud service providers!

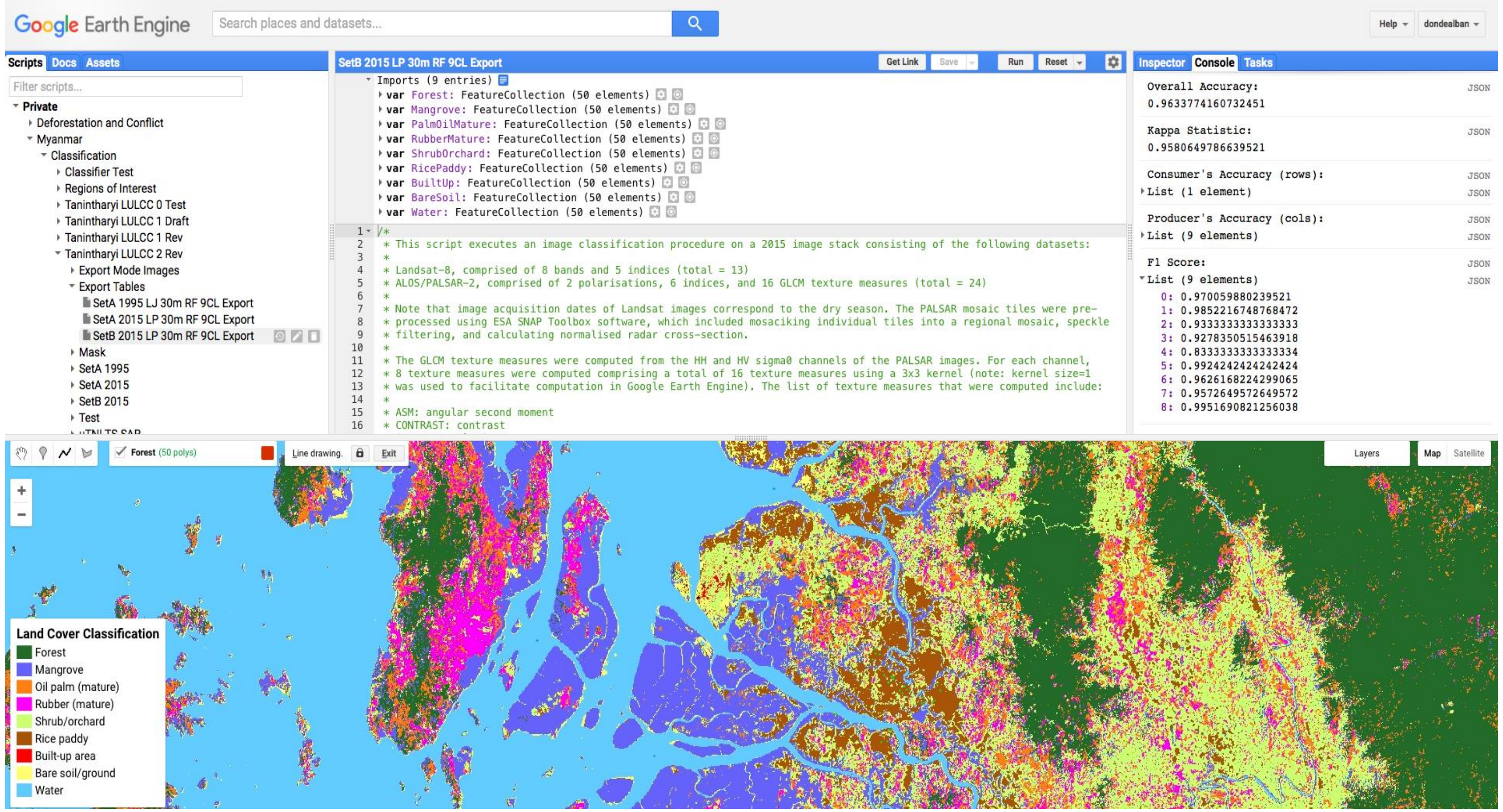
Azure · aws · Google Cloud

- Common features
  - Virtual machines
  - Cloud storage
  - Open-source software
  - Open datasets
- Different features
  - Azure Machine Learning Platform
    Cloud-based environment to train, deploy, automate, manage ML models
  - Azure Data Science Virtual Machines
    Geo AI Data Science VM with ArcGIS
  - EMR Cloud-native Big Data Platform
    EC2 + S3 clusters without provisioning, with OSS (Hadoop, Spark, etc.)
  - Google Compute Engine
    Cloud TPU (eg. ResNet-50, 90 ep.: 8 V100 GPU: 216 min, Cloud TPU V2: 7.9 min)
  - BigQuery
    BigQuery ML: create and execute ML models using standard SQL
    BigQuery GIS: analyze and visualize geodata by using standard SQL

Google Earth Engine is a gamechanger for geospatial computing

Combination of a multi-petabyte catalog of EO imagery and geospatial datasets with planetary-scale analysis capabilities available for free*.

earthengine.google.com



Geocomputing on local cloud can be efficient and cost effective

- **ITC Geospatial Computing Platform** provides GPU-enabled general purpose (8 vCPU, 32 GB RAM) and big data (72 vCPU, 768 GB RAM) units with large storage, analysis ready data, ready-to-use interactive and desktop software (1500+ packages), and shared workspaces.
- Currently serves **850+ registered users**.
- Provided **225,000+ hours** of computing since January 2021.
- Already returned **15+ times** the investment costs.
- Monthly cost is **< 200 Euro**.

The platform has also been used by IDEAMAP SUDAN
https://crib.utwente.nl

Overall, cloud computing has many benefits

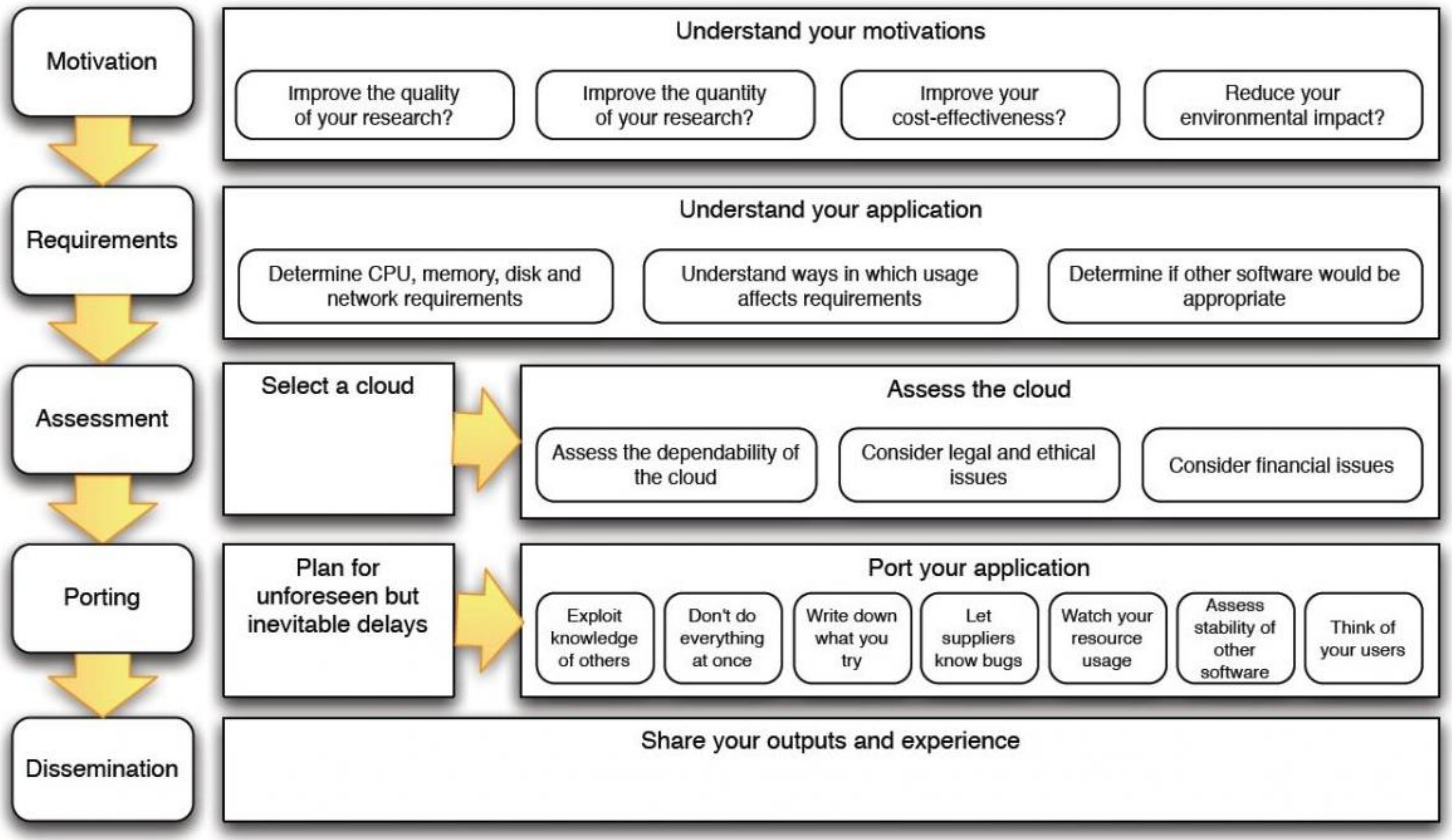
- Better computing **infrastructure** (e.g., more CPUs, GPUs, RAM)
- Better **storage** (e.g., large, replicated)
- Better **scalability** (e.g., more resources on-demand)
- Improved workflow **performance** due to co-location of data and computing (i.e., no download)
- Improved **collaboration** (e.g., direct access to same assets)
- Improved **resource utilization** (e.g., less idle time)
- **No cost** for investment and maintenance (if remote cloud)
- **Low cost** for extensive use (if local cloud)

Illustration by Storyset

A few suggestions for newcomers

- **Ensure familiarity** with the cloud computing technology through short talks and lectures.
- **Improve know-how** by participating tool- and technology-specific training
- **Try and use** the infrastructure and platforms available for free or through partner organizations.
- **Follow** a hybrid approach (local + cloud) to maximize the benefits.
- **Ask for technical and scientific support** for better implementation and integration of the technology.
- **Ask for guidance** for the planning of future activities.
- **Share your knowledge** and good practices with your colleagues (e.g., for cost-effective and efficient use).

Following best practices facilitates moving to the Cloud



Source: Best practice for using cloud in research (Hong et al., 2018)

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