
BIRDS-3


ISS


Sentinel 3A


HORYU IV

Creating CubeSat Image Database for Machine Learning based On-board Classification for Future Missions

Abhas MASKEY*,
(under Prof. Mengu CHO)

Laboratory of Spacecraft Environment Interaction Engineering (La SEINE),
Kyushu Institute of Technology, Kitakyushu, Japan

*maskey.abhas481@mail.kyutech.jp

Agenda

- Introduction & Problem Statement
- Data Collection Method
- Data Cleaning & Extension
- Results
- Conclusion & Future Work

BIRDS Introduction

- Acronym for Joint Global Multi-Nation **BIRDS** Satellite Project
  （BIRDSは多国籍型の衛星開発プロジェクトです）
- Targets non-space fairing countries
  （ターゲットは宇宙開発の経験がない国です）
- Build, test, launch and operate satellite in two years
  （開発、試験、打ち上げ、運用までを2年間で行います）

http://birds1.birds-project.com/

BIRDS-1

http://birds2.birds-project.com/

BIRDS-2

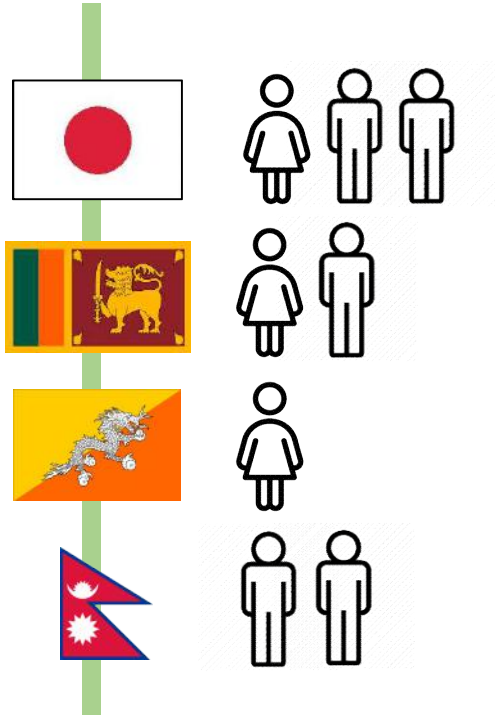
http://birds3.birds-project.com/

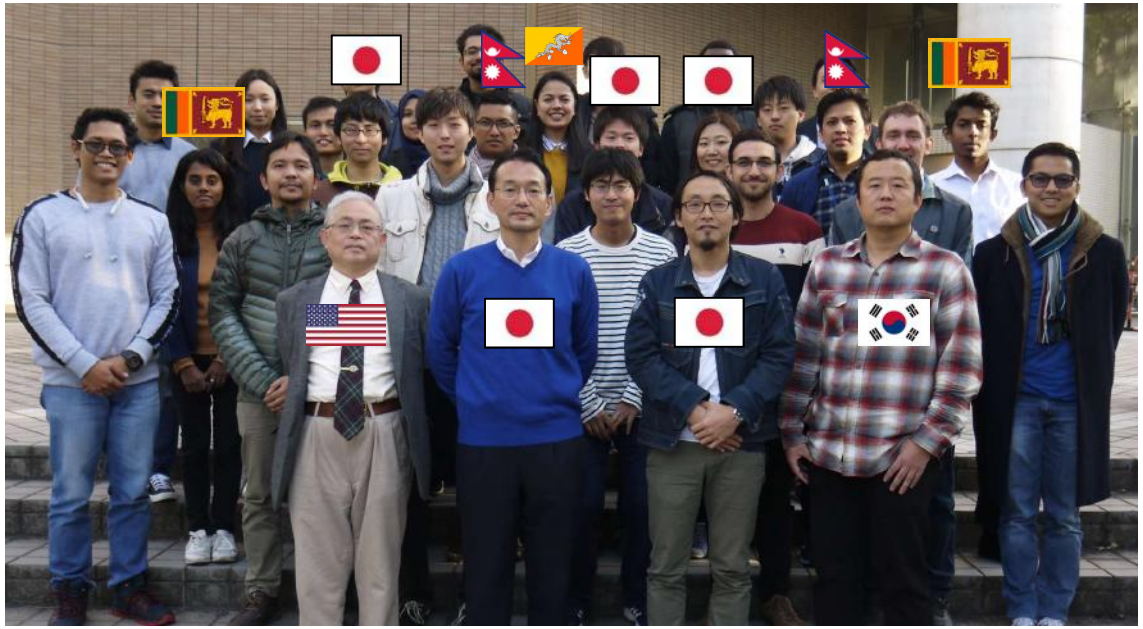
BIRDS-3

BIRDS-3 Mission and Team

BIRDS-3 Mission Statement

Successfully build Sri Lanka's and Nepal's first satellite





The Genesis

https://www.decodedscience.org/nepal-rocked-major-earthquake-m7-3-12-may-2015/54164

https://www.nytimes.com/2015/04/26/world/asia/nepal-earthquake-katmandu.html

Earthquake in Nepal (2015)

<u>Communication</u>

Pass information from A to B

<u>Remote Sensing</u>

Track landscape changes

https://thediplomat.com/2015/04/nepal-quake-governance-matters/

BIRDS-3 CAM MSN Statement

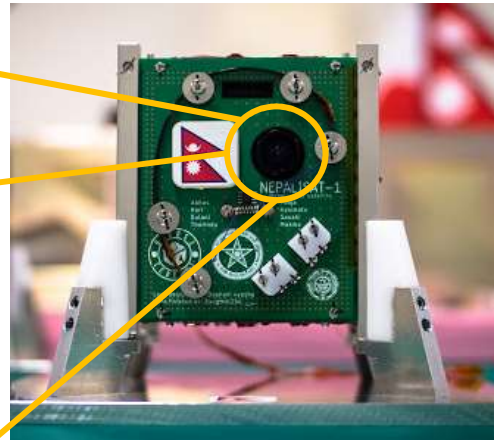
Take the first step towards remote sensing

<u>Baby Step I</u>

Take image from space

Take images primarily for outreach through traditional and social media

CAM Mission



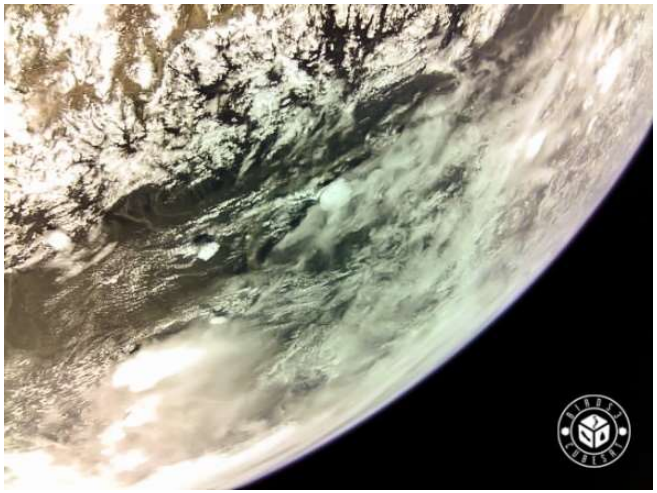
Source: BIRDS-3 Team

Images from BIRDS-3

Sri Lanka

Pacific

Mongolia



Nepal, Bhutan, Bangladesh

Parameter	Details
Resolution	640x480
GSD*	1200m
Format	JPEG
Completed	30**
Size	7~73kB

*GSD: Ground Sampling Distance
** First three months of operation

2-3 Days/Image

Source: BIRDS-3 Team

https://birds3.birds-project.com/category/outreach/

Exploring the WHY?

Downlink datarate is at 4800bps

Sharing GS* with BIRDS-2

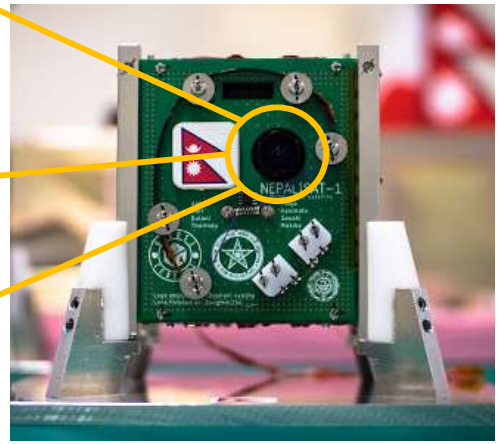
Weather conditions

GS* Repairs

10-15% Packet loss

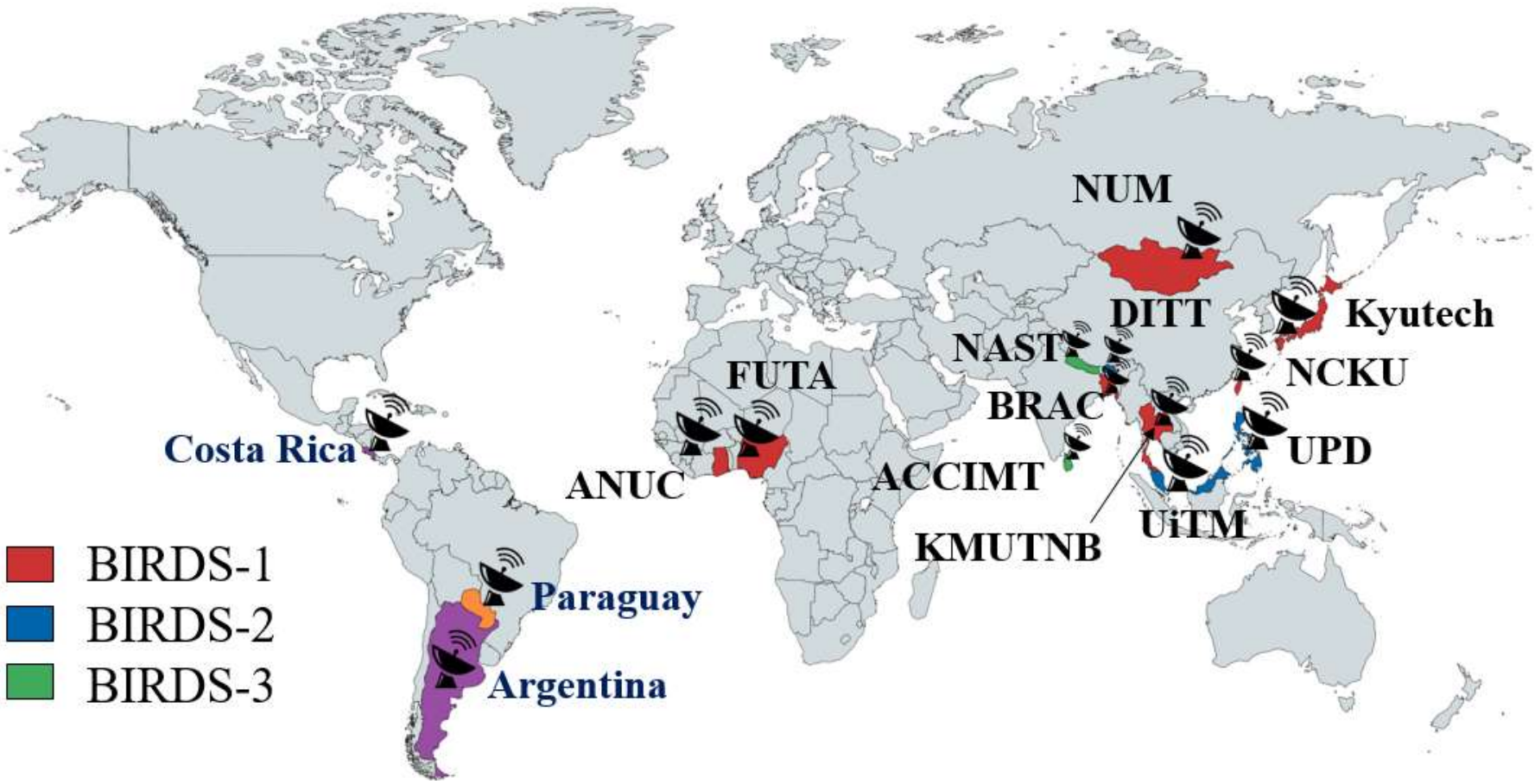
*GS: Ground Station

CAM Mission



Source: BIRDS-3 Team

Solution 1: Ground Station Network



https://mapchart.net

15 GROUND STATION MEMBERS

Solution 2: Increase Downlink Rate

Freq.	License	Bitrate	Trans. PWR	Ref. Eff.	PWR/bit	Ideal Data
UHF	Amateur	4.8kbps	0.8W	17.5%	2.6×10^{-4} mWh	700kB
UHF	Amateur	19.2kbps	2W	17.5%	1.7×10^{-4} mWh	1.12 MB
S-band	ISM	20Mbps	2W	17.5%	1.6×10^{-7} mWh	1.17 GB
X-band	Required	120Mbps	12W	17.5%	1.6×10^{-7} mWh	1.17 GB

BIRDS-3 Ref.

*EnduroSat: www.endurosat.com/modules-datasheets

Parameters	Details
Total Generation	1480mWh
Transmission PWR	0.8W
Supply Voltage	3.8V
Transmission Efficiency	17.5% (Ref. Eff.)
Over Current Protection	4A

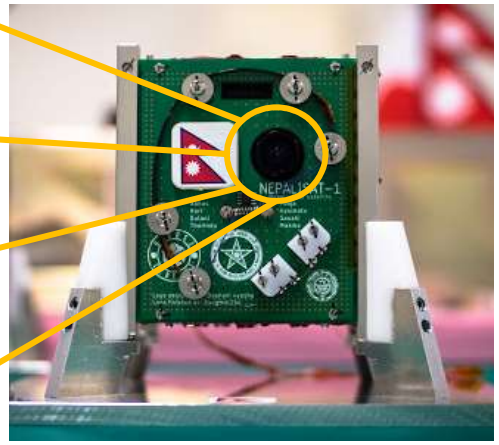
Parameters	1U CubeSat Ex.
UHF (4.8kbps)	BIRDS-3,4
UHF (19.2kbps)	ITUpSat-1
S-band	Goliat
X-band	-
Ku-band	Hayato

*Time: Ideal case, total communication time before batt runs out

Challenges for Downlink Rate

What about GS Support? Infrastructure? License?

CAM Mission



Source: BIRDS-3 Team

Link Margin?

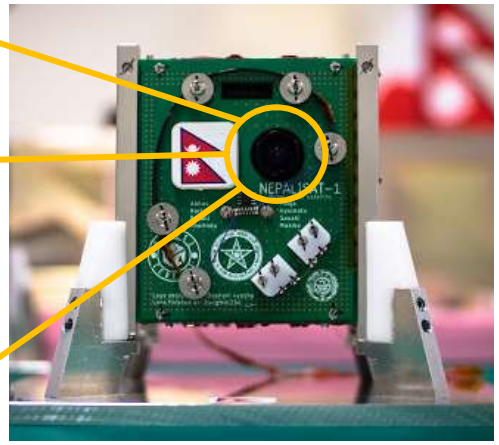
Pointing Requirements?

Conservative Measures

Quality over Quantity

CubeSat can downlink only a few MB in lifetime*

CAM Mission



Source: BIRDS-3 Team

Standardization:
BUS remains constant
GS remains constant

Need for on-board image selection
through classification

*Expanding Cubesat Capabilities with a Low Cost Transceiver
http://culair.weebly.com/uploads/4/3/1/4/43140931/palo-2014.pdf

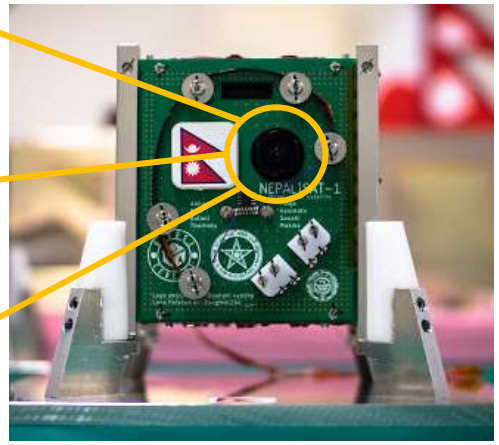
Onboard Image Selection

Classical Image Processing
Hard Coded

Traditional Machine Learning (ML)
<u>Support Vector Machine (SVM)</u>

State of Art
<u>Deep NN using CNN</u>

CAM Mission



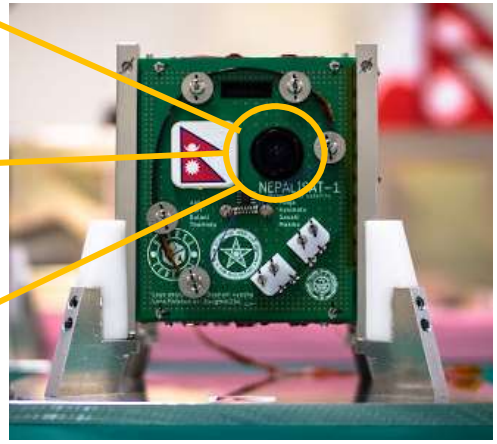
Source: BIRDS-3 Team

Deep NN: Deep Neural Network
CNN: Convolutional Neural Network

Research: Database Creation

Core Idea:
Simple, low-cost and novel method for database creation

CAM Mission



Source: BIRDS-3 Team

Novelty:
Uses open data from Sentinel 3A and ISS to create CubeSat-like images

Outcome:
15,000 ML-ready augmented images
Create database without entirely relying on other projects

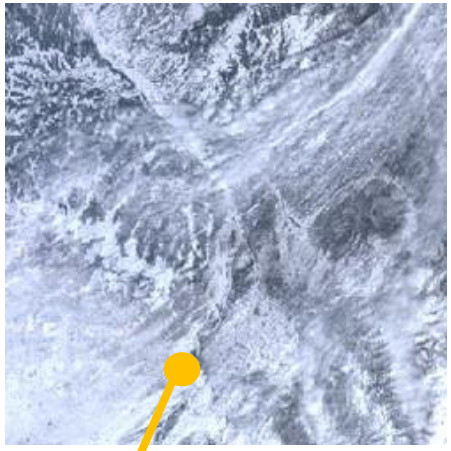
Agenda

Data Collection Method

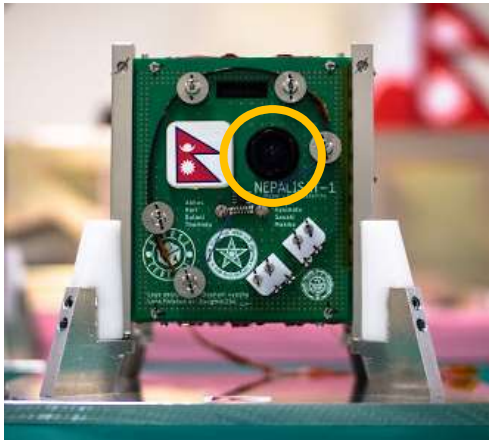
Introduction

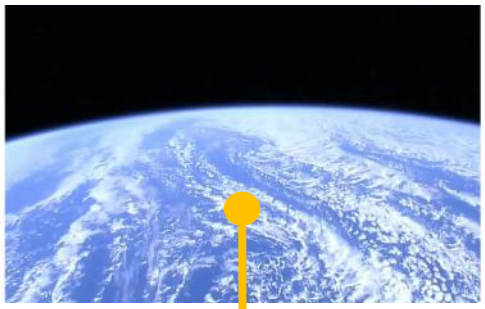
DATA COLLECTION METHOD

Image Collection: Sources

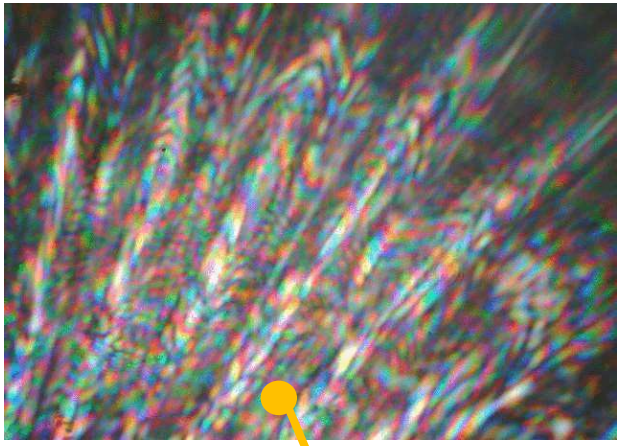


Sentinel-3A (Google Earth Engine)



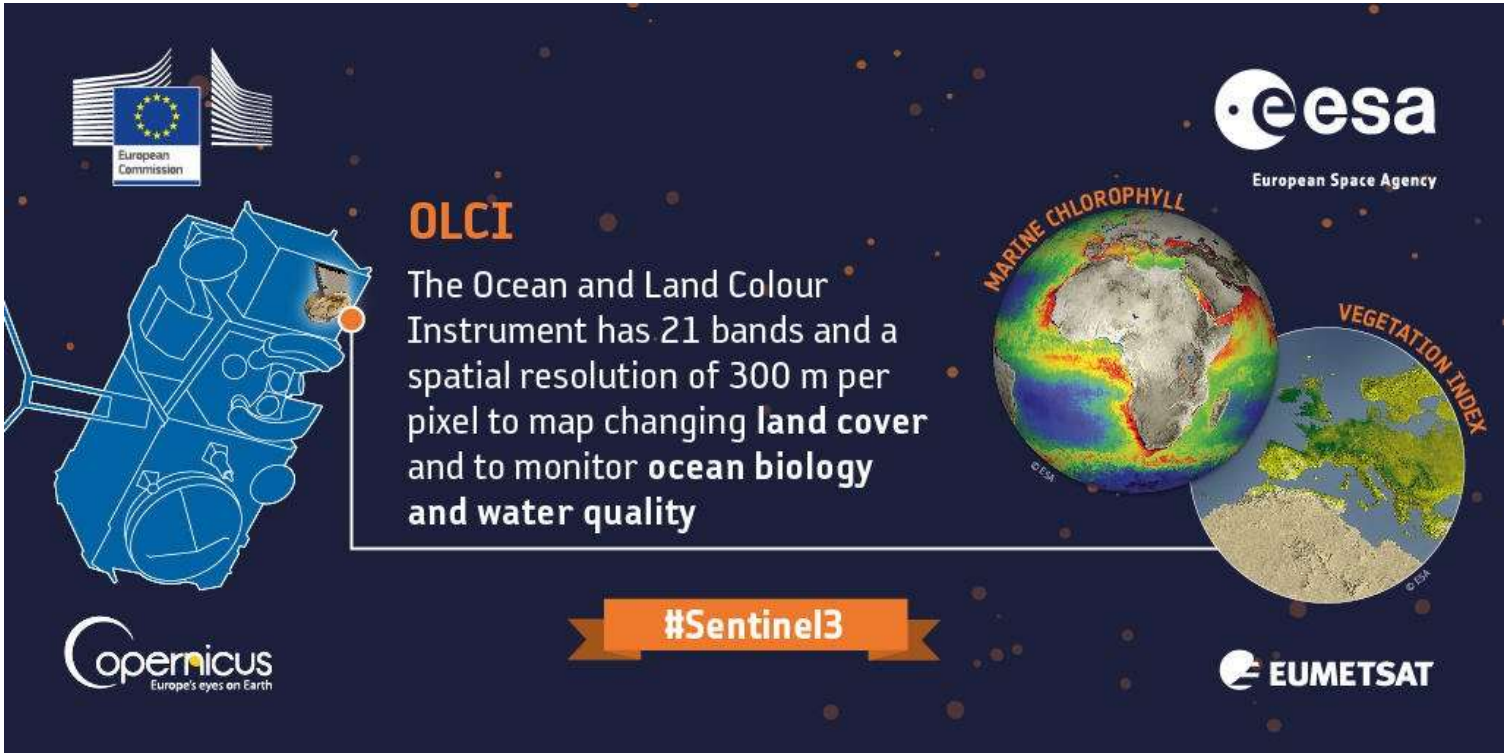


ISS images



Kyutech's internal database

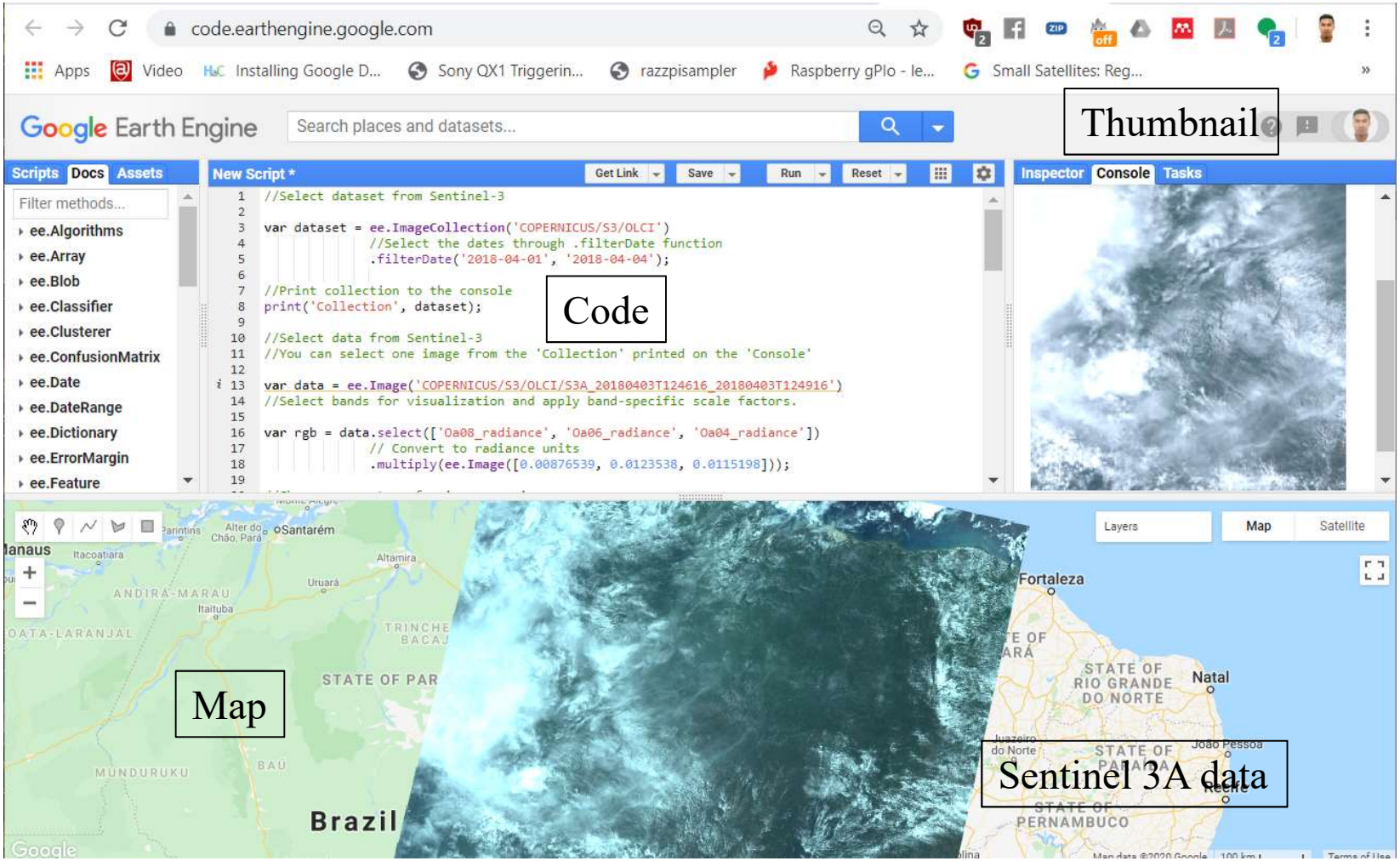
1) Sentinel 3A



https://twitter.com/ESA_EO

SLSTR (Sea and Land Surface Temperature Radiometer)
OLCI (Ocean and Land Colour Instrument)
SRAL (SAR Altimeter)
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite)
MWR (Microwave Radiometer)

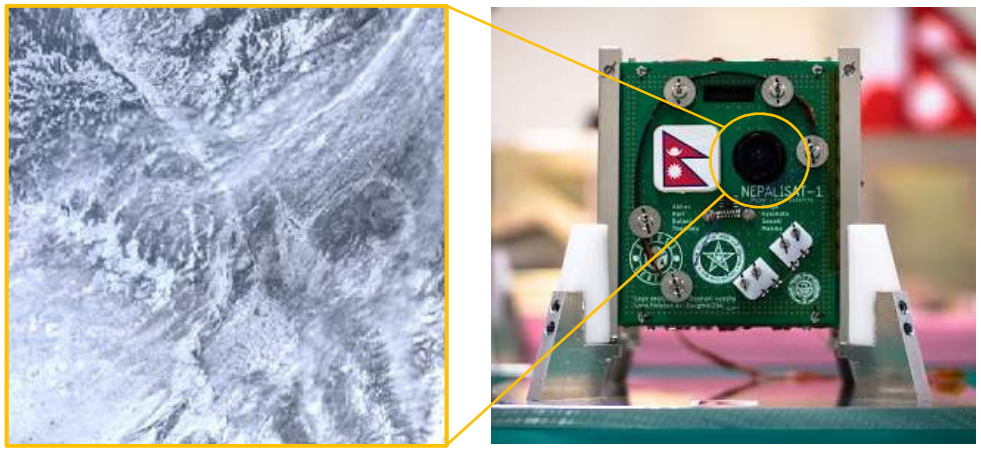
Google Earth Engine (GEE)

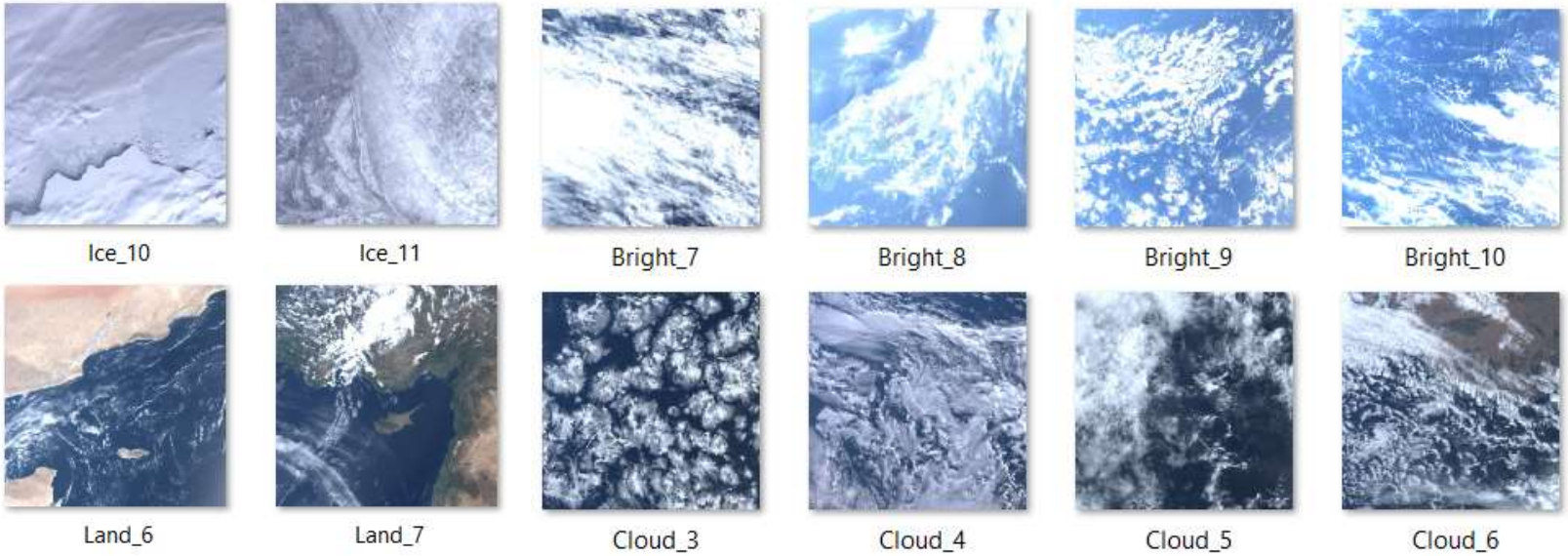


https://code.earthengine.google.com/

Example code provided in the Appendix section of paper

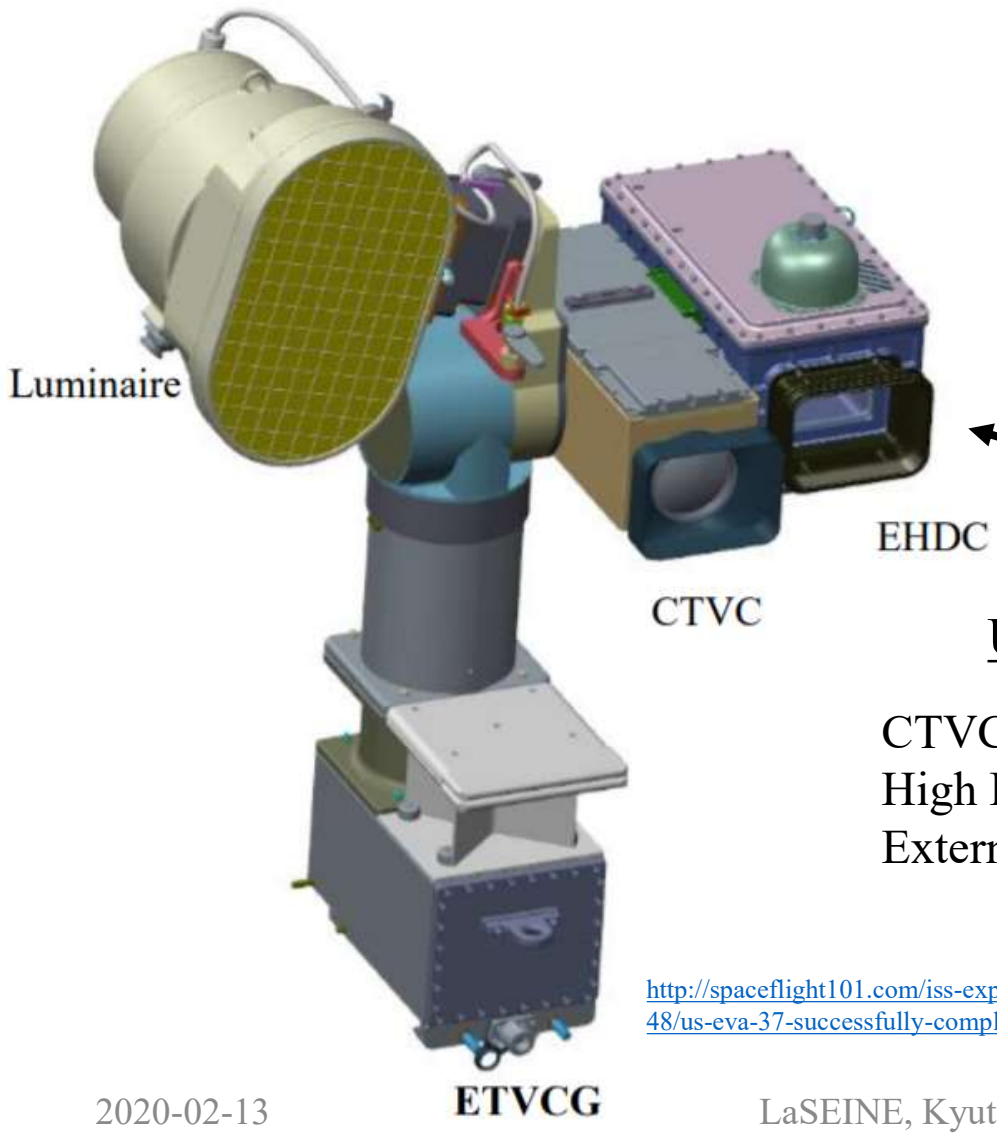
Nadir-Pointed Image Generation





2) International Space Station (ISS)

http://spaceflight101.com/iss-expedition-48/us-eva-37-successfully-completed-on-iss/



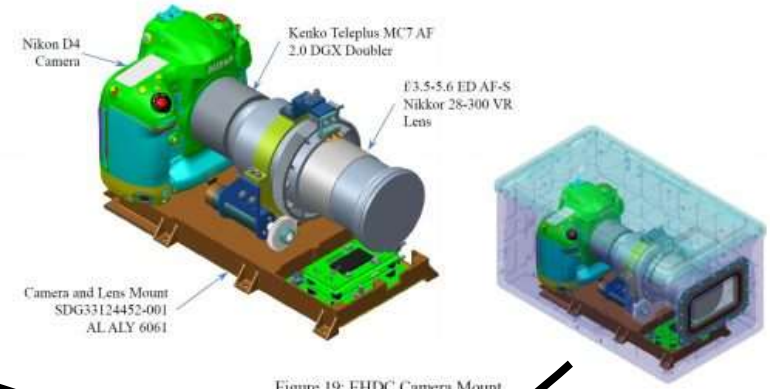


Figure 19: EHDC Camera Mount

Use of cameras installed on ISS

CTVC
High Definition Earth Viewing System (HDEV)
External High Definition Camera (EHDC)

Horizon Images

http://spaceflight101.com/iss-expedition-48/us-eva-37-successfully-completed-on-iss/

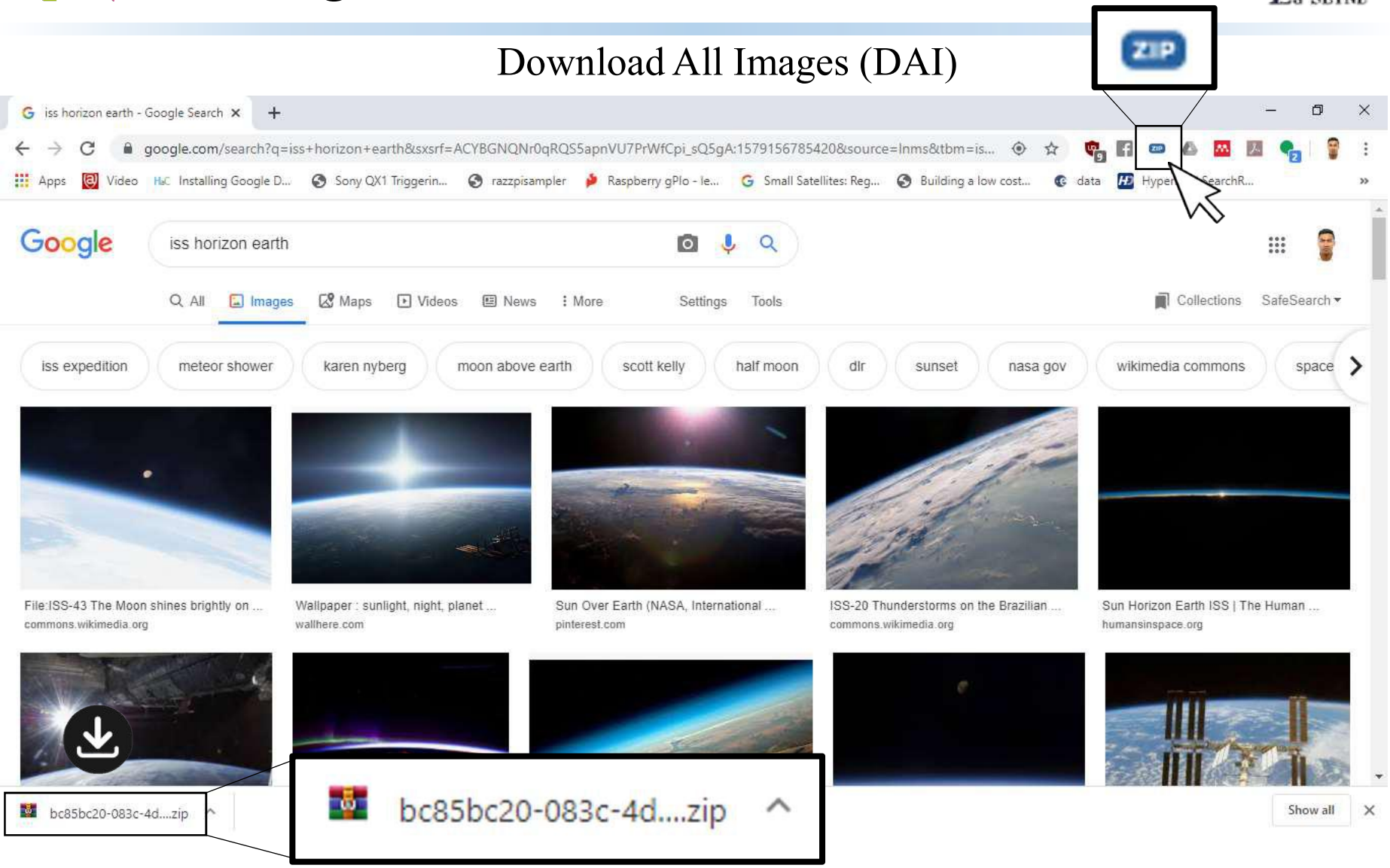
International Space Station (ISS)

Video Feed

https://youtu.be/TyVWcPy9aXk

Using Chrome Extension: DAI

Download All Images (DAI)



Horizon Images from ISS


Horizon-1.jpg


Horizon-2.jpg


Horizon-3.jpg


Horizon-4.jpg


Horizon-5.jpg


Horizon-8.jpg


Horizon-9.jpg


Horizon-10.jpg


Horizon-11.jpg


Horizon-12.jpg


Horizon-15.jpg


Horizon-16.jpg

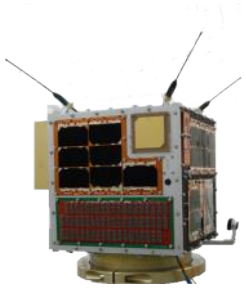
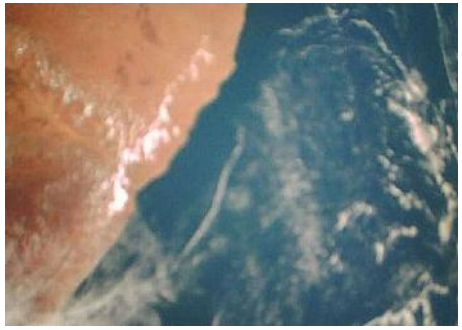

Horizon-17.jpg

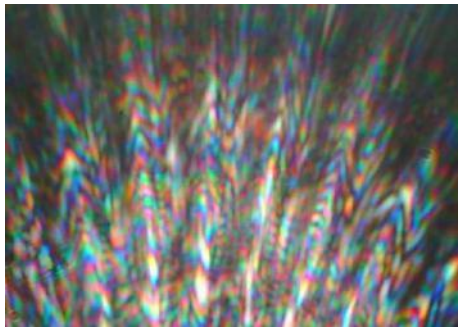

Horizon-18.jpg


Horizon-19.jpg

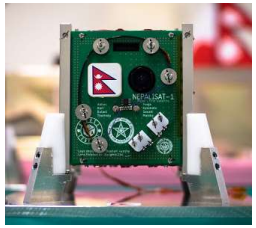
3) Kyutech Internal Image Database

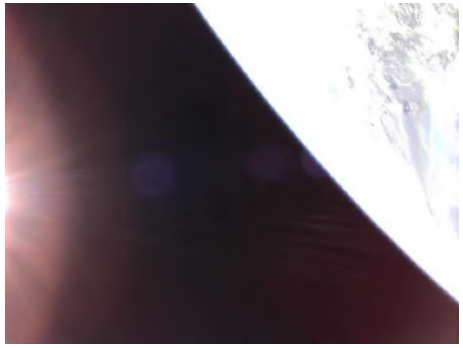
HORYU IV



BIRDS-3






Agenda

Data Collection Method

Introduction

Cleaning & Extension

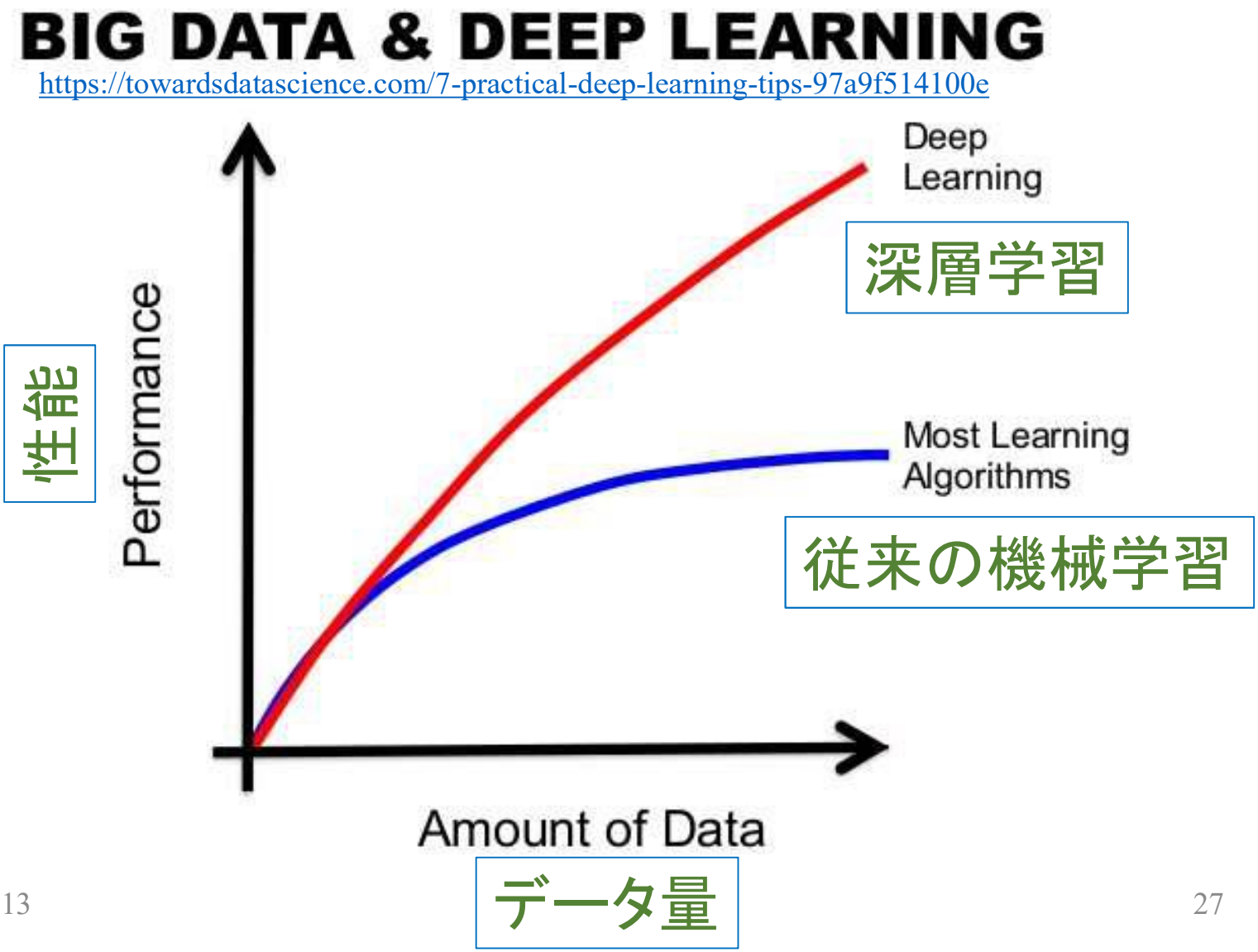
DATA CLEANING & EXTENSION

Data Conditioning (1)

<u>The model is only as good as the data that's been fed</u>

Uniformity Resizing **Cleaning**

Performance vs Amount of Data



Data Augmentation (1)

Widely applied technique to increase data

一般的な手法

Increases invariance

不変性を増加させる

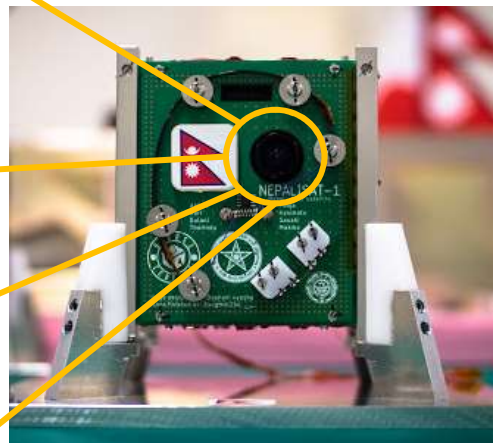
Increases regularization

正則化を高める

Increases adaptability

適応性を高める

CAM Mission



Source: BIRDS-3 Team

Supporting Vocabulary

Invariance

Model can classify better when image orientation is different

Regularization

Combat Overfitting

Overfitting

Tuned to classify training data much better than test data

Adaptability

Can adapt when original architecture changes

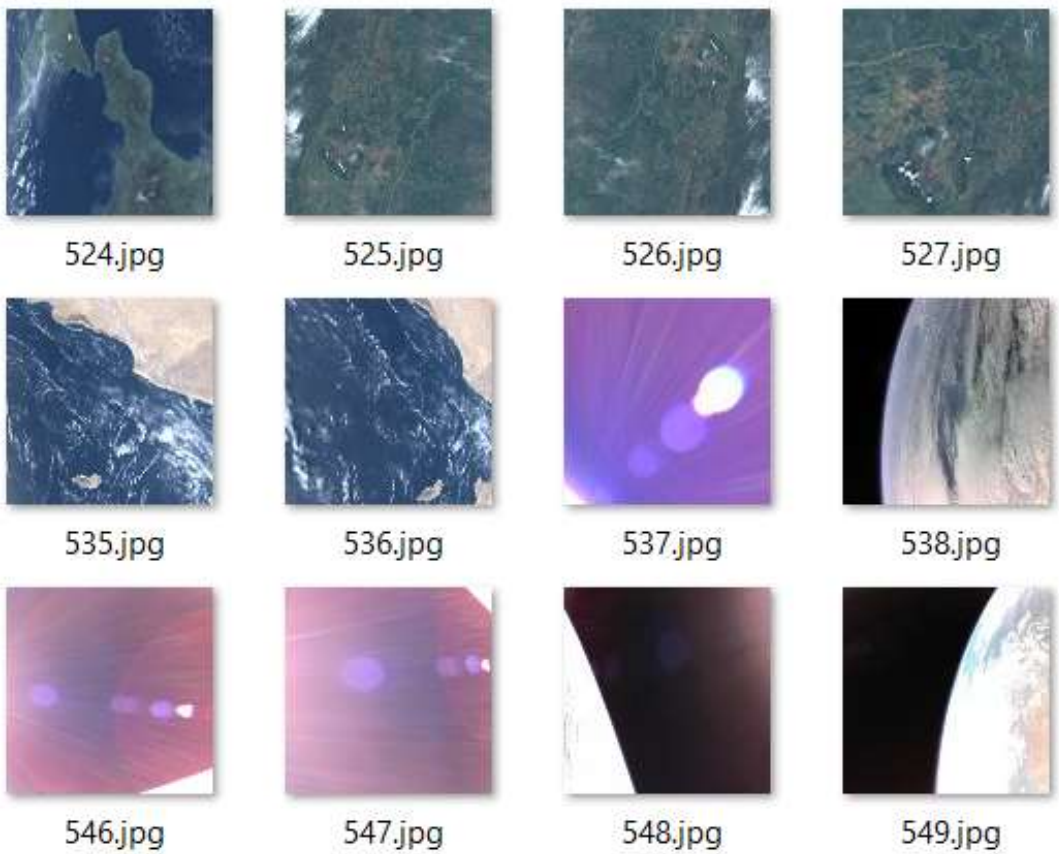
Data Augmentation (2)

Rotation + Flipping + Distortion + Skewing = 15,000

https://github.com/mdbloice/Augmentor

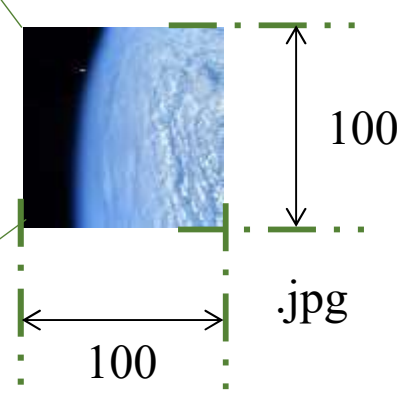
Marcus D Bloice, Peter M Roth, Andreas Holzinger, Biomedical image augmentation using Augmentor, *Bioinformatics*, https://doi.org/10.1093/bioinformatics/btz259

Data Conditioning (2)



Uniformity

Resizing



Agenda

Data Collection Method

Results

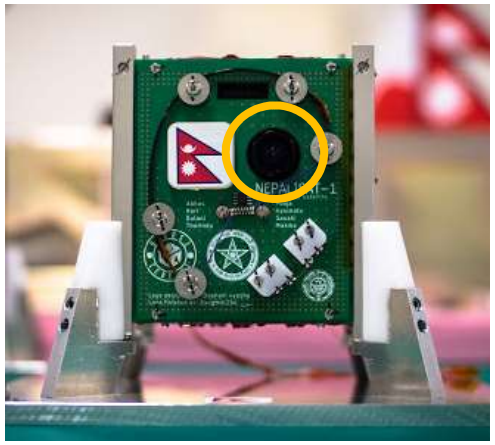
Introduction

Cleaning & Extension

RESULTS

Results

Parameters	Source	Count
Horizon images	ISS	150
Nadir pointed images	Sentinel 3A	100
Real satellite imagery	BIRDS-3	30
Real satellite imagery	HORYU IV	120
Total		400
Total Augmented Images		15,000



Horizon Earth

BIRDS-3 ISS Sentinel 3A HORYU IV

Generated

Agenda

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Results

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Conclusion & Future Work

Conclusion & Future Work

Conclusion & Future Work

- Explored simple way of creating dataset from scratch
- Used open data freely available from the internet
- Used free software where possible (low-cost)
- Automatize data selection, save time and labour

<u>Future Work</u>

- Extend the image database to 60,000
- Create ML model and use the database to train
- Deploy and test the model for real impact

THANK YOU