

# Quantum Processing of Big Data: From Quantum Computing to Earth Observation

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# Background - Why are we here?



1. European Space Agency  $\Phi$ -Lab - *Accelerate the future of Earth Observation*

2.  $\Phi$ -Week (1<sup>st</sup> workshop on QC for EO)

1. Explore possible synergies between QC & EO
2. with a view to stimulate their further development
3. ... and accelerate their impact for societal benefit



3. 5<sup>th</sup> Quantum Technologies Conference

## $\Phi$ -Week QC4EO Conclusions:

### • Current Status

- QC developing rapidly (China: 10b, US: 1.25b/5y, EU: 1b/10y)
- EO experiencing paradigm shift (commercialisation of space, Big Data, AI)

### • Opportunities, Challenges, Recommendations

- Challenge = maturity: EO start-ups look for QC advantage/supremacy
- Recommendations = increased dialogue between QC and EO (to understand mutual requirements and capabilities)



# Objectives – What do we want from this event?



*Focus of workshop on QC for downstream EO (**not sensing**, but **data management** for scientific and operational applications)*

1. **Bring together** QC and EO communities (needs, capabilities, limitations, future opportunities)
  1. Quantum Computing (far from fault tolerant, universal? Timeline?)
  2. Earth Observation (Big Data, Newspace, Copernicus, AI)
2. **Explore Synergies** between EO & QC
  1. Applicability (Any intractable - NP-Complete - problems in EO?)
  2. Technical Opportunities (QC advantage / supremacy in general, and for EO specific problems?)
  3. Use Cases?
    1. Upstream (general data processing)
    2. Downstream domain specific
3. **Make (actionable) recommendations** on ways to stimulate QC & EO fusion for European competitiveness & societal benefit
  1. Encourage information exchange e.g. workshops (an aim of COST Action QTSpace)
  2. Stimulate innovation: e.g. challenges (Kaggle competition) with industry?
  3. Build capacity (outreach, training)
  4. Exploit funding opportunities: Q Flagship, ESA Open Call, Newspace commercial interest



Wednesday 3 April	
09.00-09.30	<b>Registration and Coffee break</b>
09.30-09.40	<b>Welcome and Introduction</b>
09.40-09.55	<b>Earth Observation Opportunities and Challenges</b> Chris Stewart, Sveinung Loekken, Gordon Campbell, <i>European Space Agency</i>
09.55-10.10	<b>Quantum Information Processing: Opportunities and Challenges</b> Mauro Paternostro, <i>Queen's University Belfast</i>
10.10-10.30	<b>Quantum Resources for EO Technology</b> Mihai Datcu, <i>German Aerospace Agency (DLR)</i>
10.30-10.50	<b>Quantum Computing for EO Mission Planning</b> Mathieu Picard <i>Airbus</i>
10.50-11.10	<b>HPC for Spacestream: The Future of EO!</b> Cristoforo Abbattista, <i>Planetek</i>
11.10-11.40	<b>Coffee break</b>
11.40-12.00	<b>Quantum Computing for Aerospace Applications</b> Tobias Stollenwerk, <i>German Aerospace Agency (DLR)</i>
12.00-12.20	<b>Deep Learning for Earth Observation</b> Andrea Pomente & Leonardo De Laurentiis, <i>University of Rome Tor Vergata</i>
12.20-13.40	<b>Lunch</b>
13.40-14.10	<b>From Quantum Machine Learning to Quantum AI</b> Vedran Dunjko, <i>Leiden University</i>
14.10-14.40	<b>Quantum Machine Learning with Quantum Technologies</b> Lucas Lamata, <i>University of the Basque Country</i>
14.40-15.00	<b>The Born Supremacy: The Training and Quantum Advantage of the Ising Born Machine Learning</b> Daniel Mills, <i>The University of Edinburgh</i>
15.00-15.20	<b>Integrated Photonic Platform for Quantum Machine Learning</b> Nicolò Spagnolo, <i>La Sapienza Università di Roma</i>
15.20-16.00	<b>Panel discussion and closing remarks</b>

## 2. What synergies are there between QC & EO?

1. EO oriented: What are the intractable problems in EO that could be addressed by QC?
2. Quantum oriented: Are there quantum optimisation algorithms relevant to EO data science?
3. Are there domain specific synergies: e.g. climate modelling, land cover classification, disaster monitoring?
4. Synergies for on-board processing
5. Synergies to help EO mission planning

## 3. Are there specific needs that could be addressed?

1. Community needs (data / processing requirements)
2. Societal challenges
3. Moonshots (unrealistic, but would be great!)

## 4. What recommendations do you have to stimulate joint development of QC&EO?

1. What could ESA do to stimulate European competitiveness in research and application of QC with EO?
2. How could available programs and funding opportunities be exploited?
3. What are the first steps?

# Round Table: Questions you will be asked ...



1. Are these really the right questions? And if not, what are the questions we should be asking at this time?

