ECMWF FOUR YEAR PROGRAMME: **2021 – 2024 I STRATEGY 2021 – 2030**

Science and Technology

- World Leading Weather and Earth system Science
- Cutting Edge Technology and Computational Science for NWP

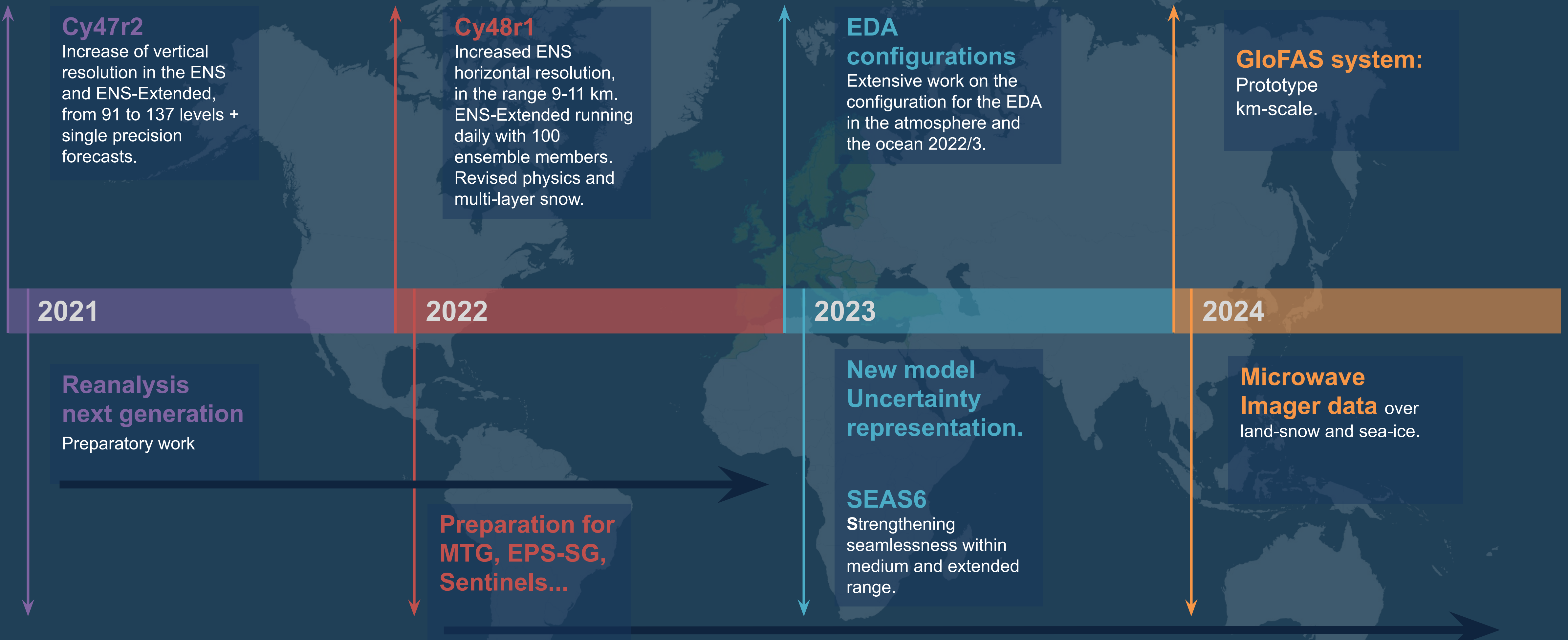
Impact

- High quality products fit for purpose
- Efficient & easy access to products

Organisation and People

- Efficient organisation
- Focus on people

ECMWF FOUR YEAR PROGRAMME: WORLD LEADING WEATHER AND EARTH SYSTEM SCIENCE



2021

Cy47r2
Increase of vertical resolution in the ENS and ENS-Extended, from 91 to 137 levels + single precision forecasts.

Reanalysis next generation
Preparatory work

2022

Cy48r1
Increased ENS horizontal resolution, in the range 9-11 km. ENS-Extended running daily with 100 ensemble members. Revised physics and multi-layer snow.

Preparation for MTG, EPS-SG, Sentinels...

2023

EDA configurations
Extensive work on the configuration for the EDA in the atmosphere and the ocean 2022/3.

New model Uncertainty representation.

SEAS6
Strengthening seamlessness within medium and extended range.

2024

GloFAS system:
Prototype km-scale.

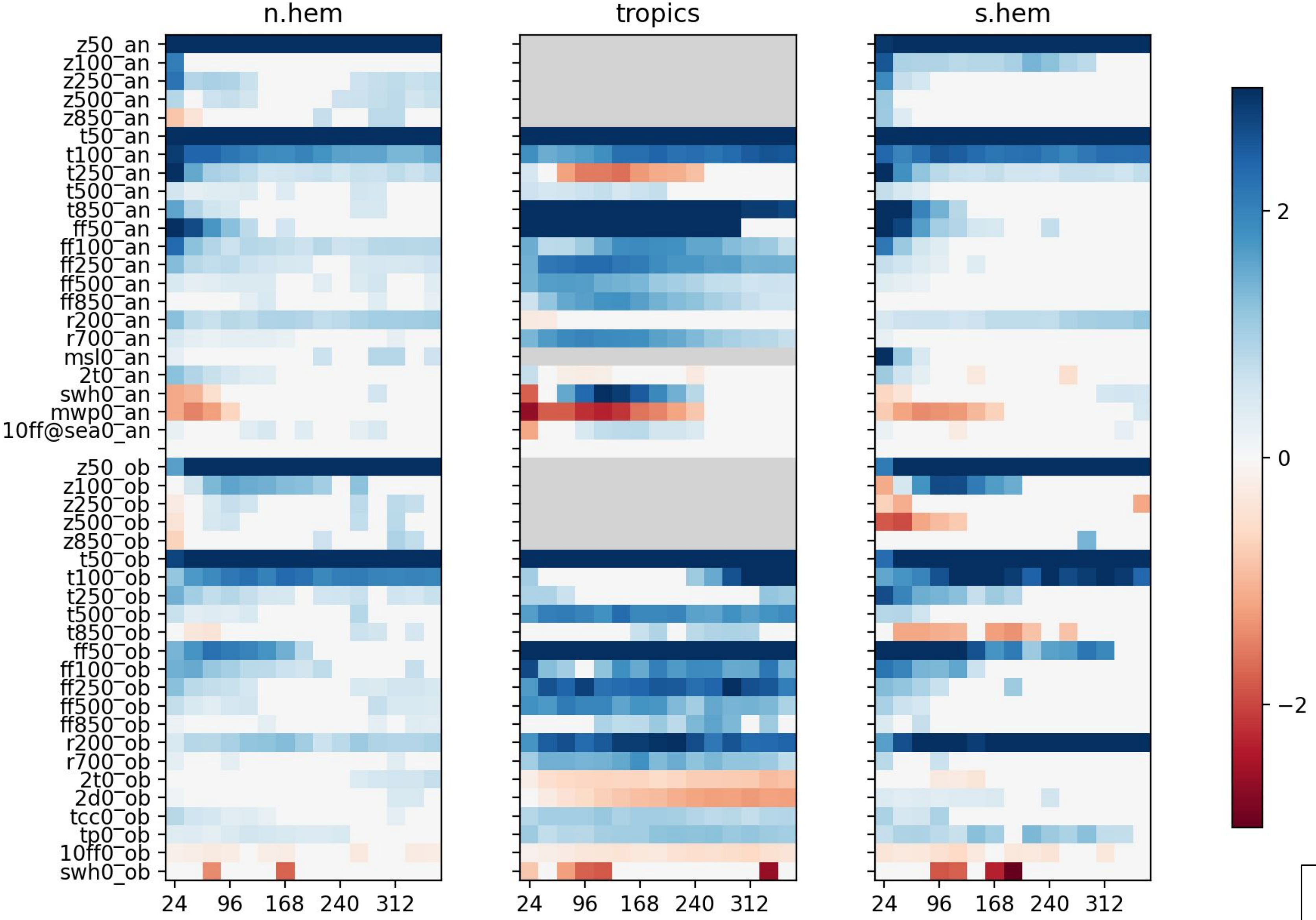
Microwave Imager data over land-snow and sea-ice.

Future Cycles

Common interests in improving process for development and testing of cycles (github, continuous integration, cross-testing etc etc)

	SAC 2019	SAC 2020
47r2 (Spring 2021)		Single precision (HRES fc, ENS, extended-range) Unified vertical resolution (ENS, extended-range to L137)
48r1 (2022)	Single precision (HRES fc, ENS, extended-range) Unified vertical resolution (ENS, extended-range to L137) ENS horizontal resolution increase to 9-11 km Daily extended-range ensembles (ideally 51 members) Moist physics upgrade, multi-layer snow scheme	ENS horizontal resolution increase to 9-11 km Daily extended-range ensembles (100 members) Moist physics upgrade, multi-layer snow scheme OOPS (multi-executable) operational implementation
49r1 (2023)	COPE and OOPS operational implementation NEMO 4, SI3 Multi-layer surface variables / multi-layer soil scheme	COPE operational implementation NEMO 4, SI3 Multi-layer surface variables / multi-layer soil scheme New model uncertainty representation

Impact of L137, Single Precision on ENS

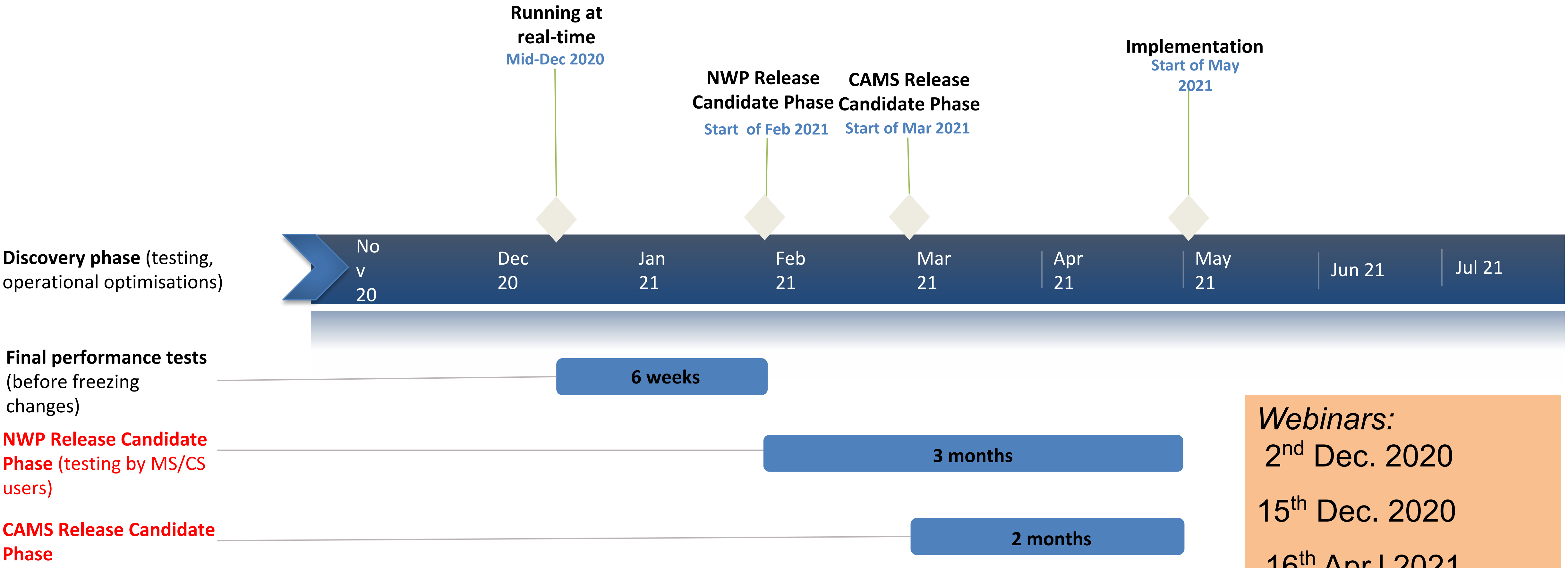


Summer + winter
168 initialization dates

Timelines

Implementation of cycle 47r2

Impacts on – but benefits for – LAM ensembles



Discovery phase (testing, operational optimisations)

Final performance tests (before freezing changes)

NWP Release Candidate Phase (testing by MS/CS users)

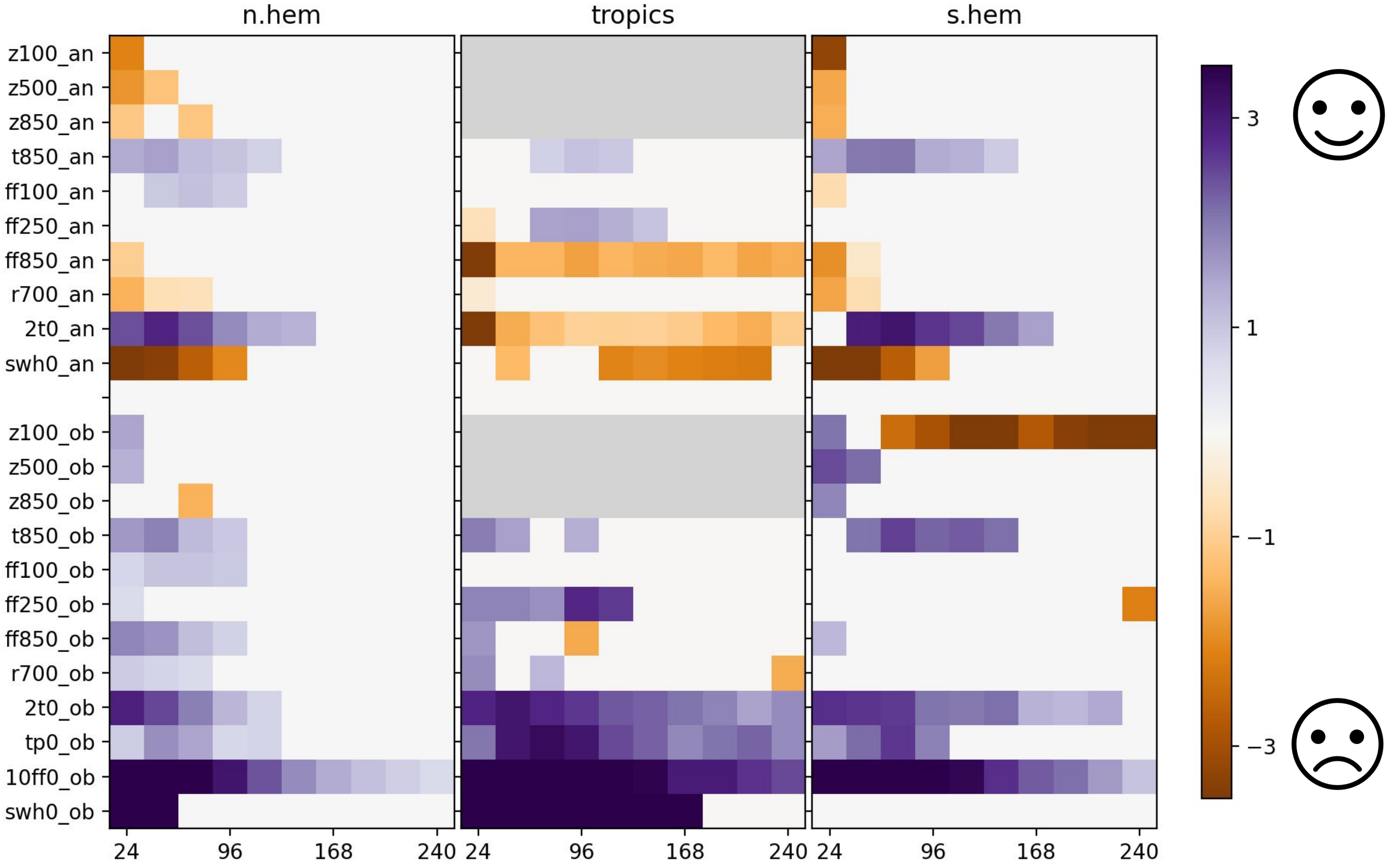
CAMS Release Candidate Phase

Webinars:
2^{nd} Dec. 2020

15^{th} Dec. 2020

16^{th} Apr.l 2021

New model uncertainty representation: SPP versus operational SPPT scheme

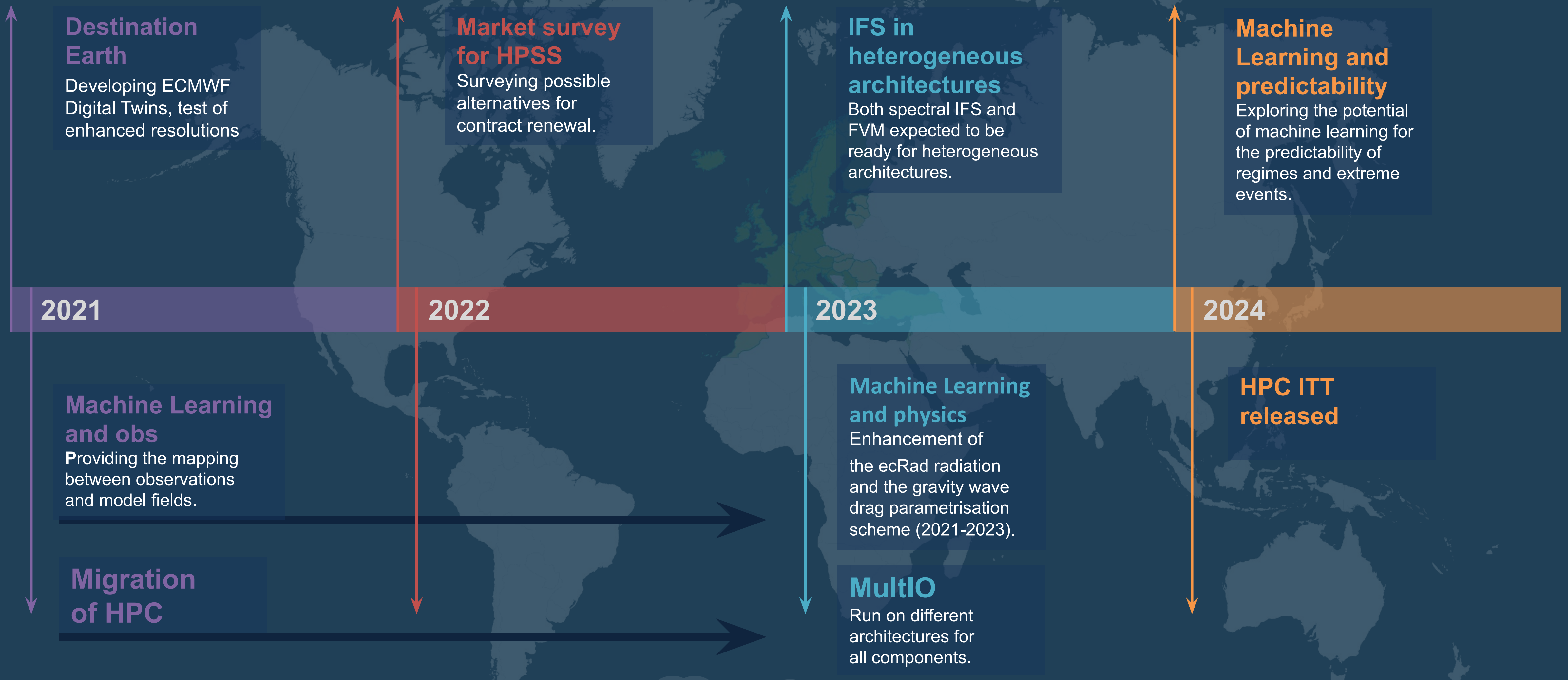


Technical work commenced to re-design the SPP code to share the IFS perturbation model infrastructure with LAM applications.

Will ease maintenance and enhance future collaborations.

Increased physics collaboration

ECMWF FOUR YEAR PROGRAMME: COMPUTATIONAL SCIENCE FOR NWP



Destination Earth
Developing ECMWF Digital Twins, test of enhanced resolutions

Machine Learning and obs
Providing the mapping between observations and model fields.

Migration of HPC

Market survey for HPSS
Surveying possible alternatives for contract renewal.

IFS in heterogeneous architectures
Both spectral IFS and FVM expected to be ready for heterogeneous architectures.

Machine Learning and physics
Enhancement of

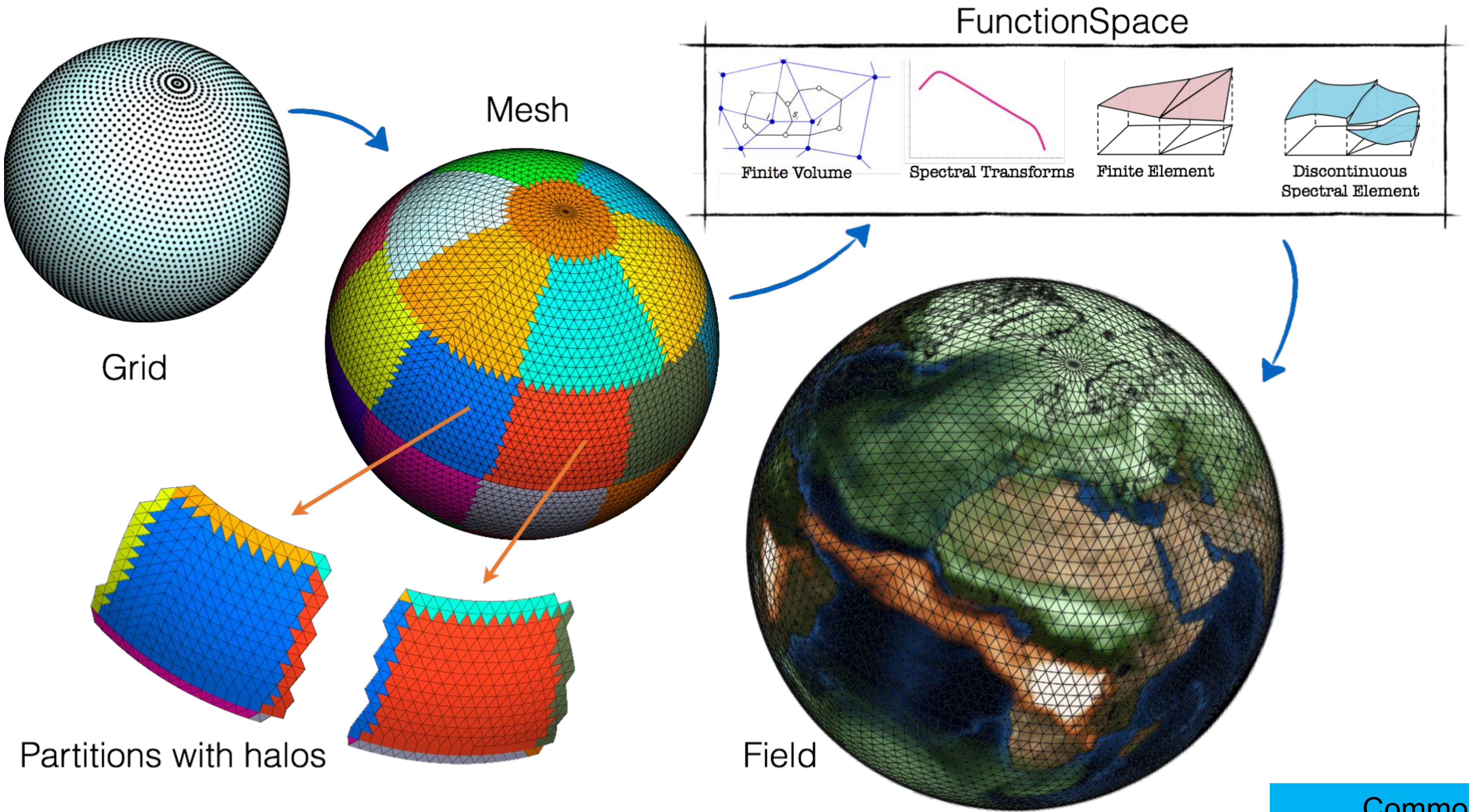
the ecRad radiation and the gravity wave drag parametrisation scheme (2021-2023).

MultIO
Run on different architectures for all components.

Machine Learning and predictability
Exploring the potential of machine learning for the predictability of regimes and extreme events.

HPC ITT released

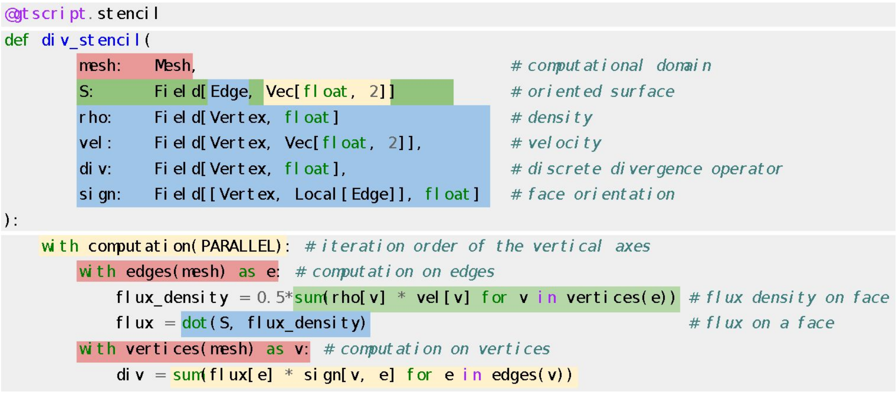
Adaptation to future HPC: ATLAS library



Common interests (e.g. ability to exploit hybrid CPU-GPU infrastructures)

Adaptation to future HPC: New FVM dynamical core option

- First prototypes implemented of IFS-FVM in the GT4Py/GT DSL of ETHZ+CSCS
- Goal for 2022 is DSL rewrite of the full global FVM

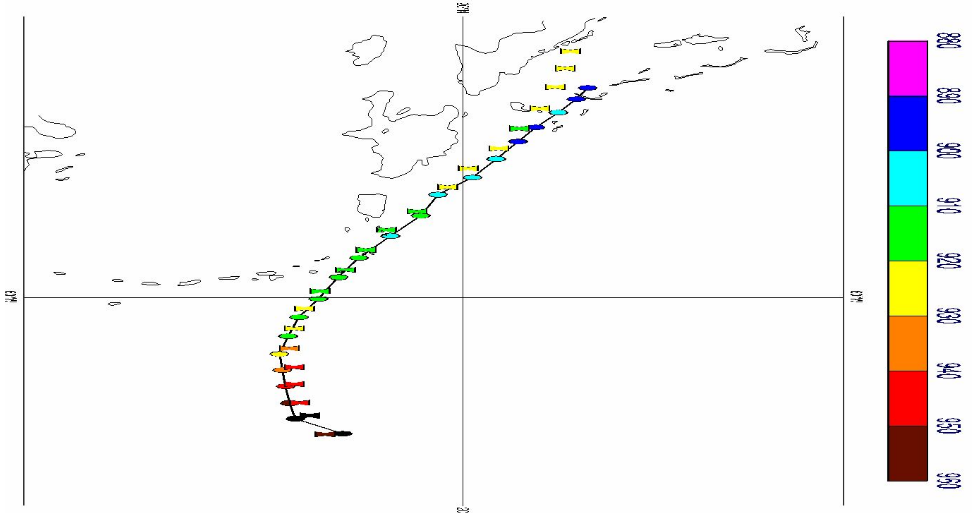


```
@gtscript.stencil
def div_stencil(
        mesh:   Mesh,                                # computational domain
        S:      Field[Edge, Vec[float, 2]]           # oriented surface
        rho:    Field[Vertex, float]                 # density
        vel:    Field[Vertex, Vec[float, 2]],        # velocity
        div:    Field[Vertex, float],                # discrete divergence operator
        sign:   Field[[Vertex, Local[Edge]], float]  # face orientation
):
    with computation(PARALLEL): # iteration order of the vertical axes
        with edges(mesh) as e: # computation on edges
            flux_density = 0.5*sum(rho[v] * vel[v] for v in vertices(e)) # flux density on face
            flux = dot(S, flux_density)                                  # flux on a face
        with vertices(mesh) as v: # computation on vertices
            div = sum(flux[e] * sign[v, e] for e in edges(v))
```

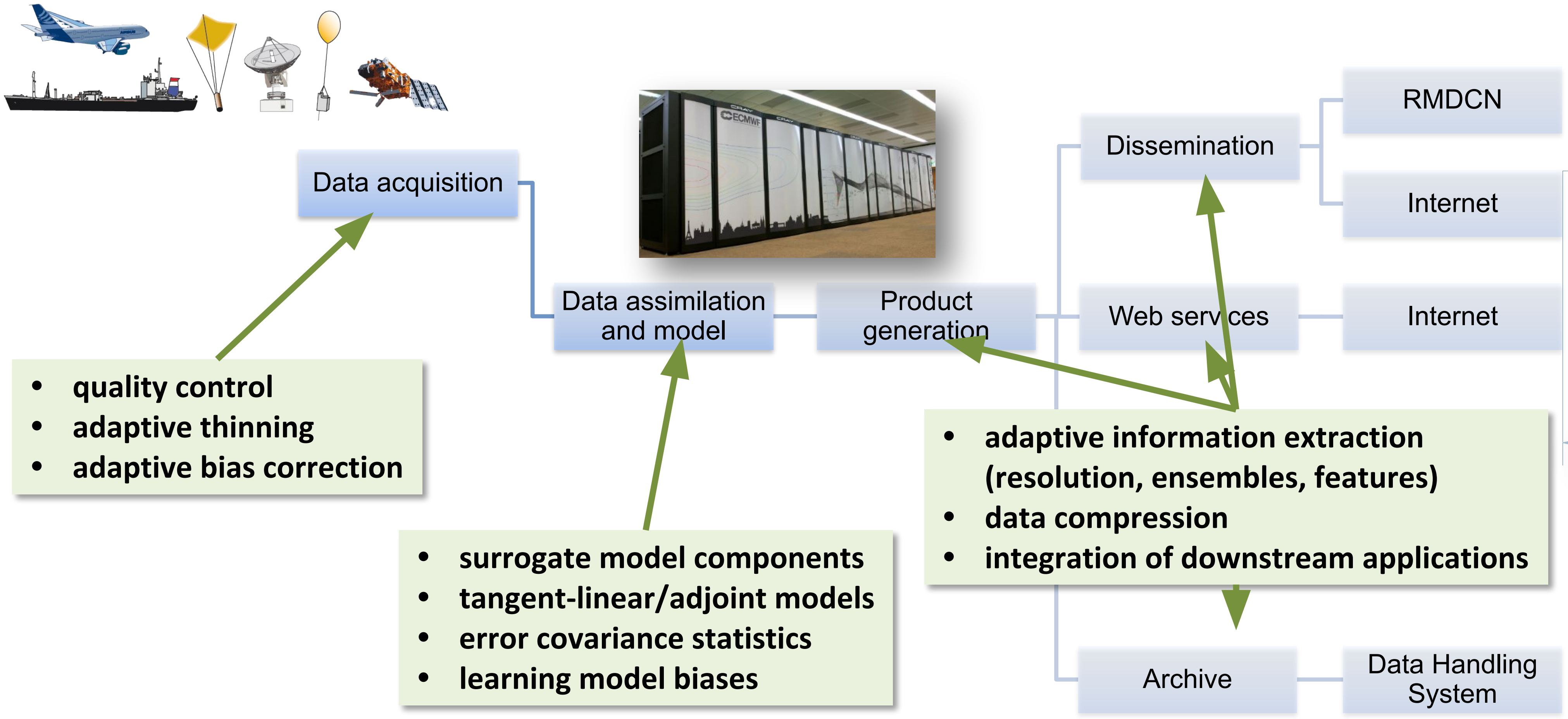
FVM design / coding to consider LAM implications

FVM-LAM work in RWP

- Coupled to radiation
- Infrastructure for super-stepping physics
- Case study tests (e.g. 120 hour forecast for Hurricane Irma at ~9km resolution from operational ECMWF analysis



Investigating the potential of machine learning



Data acquisition

Data assimilation and model

Product generation

Dissemination

RMDCN

Internet

Web services

Internet

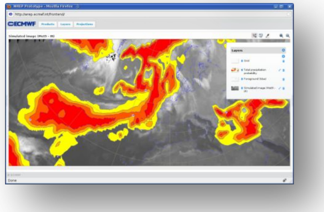
Archive

Data Handling System

- **quality control**
- **adaptive thinning**
- **adaptive bias correction**

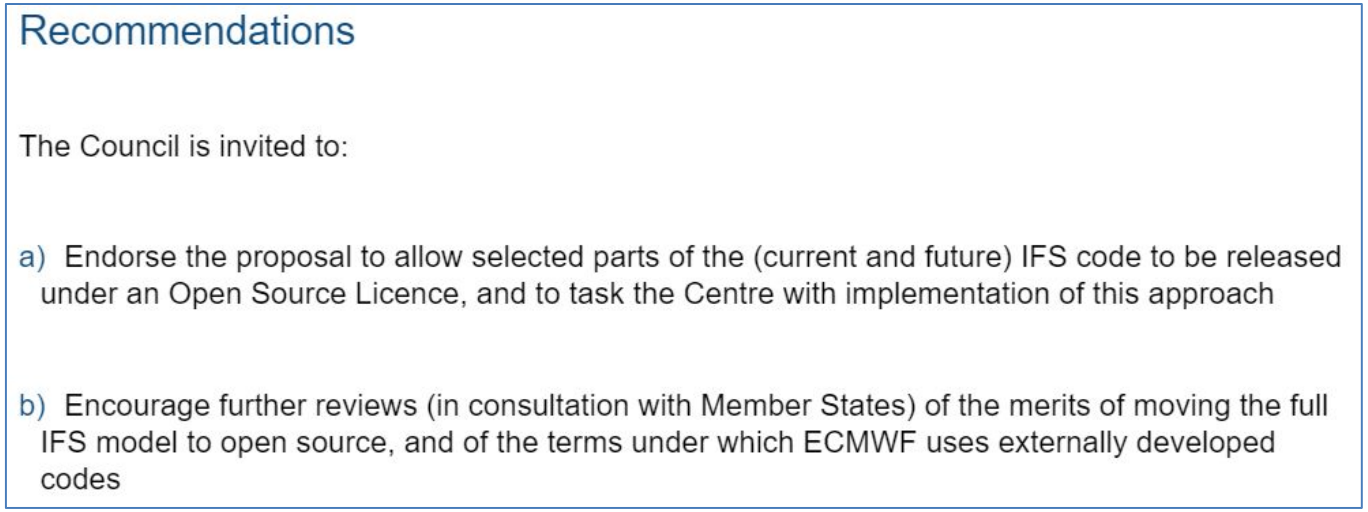
- **surrogate model components**
- **tangent-linear/adjoint models**
- **error covariance statistics**
- **learning model biases**

- **adaptive information extraction (resolution, ensembles, features)**
- **data compression**
- **integration of downstream applications**



Potential joint interests in application of machine learning at different points in production chain

IFS licence



Recommendations

The Council is invited to:

a) Endorse the proposal to allow selected parts of the (current and future) IFS code to be released under an Open Source Licence, and to task the Centre with implementation of this approach

b) Encourage further reviews (in consultation with Member States) of the merits of moving the full IFS model to open source, and of the terms under which ECMWF uses externally developed codes

Approved by Council
June 2020

First releases (APACHE-2):
radiation; spectral transforms

Any further evolution to be in consultation with MS (especially those with whom we share code)

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