



FUTURE
CIRCULAR
COLLIDER

HANDLING GEODETIC CHALLENGES AT CERN

B. Weyer CERN/BE-GM
FCC week 2022, Paris

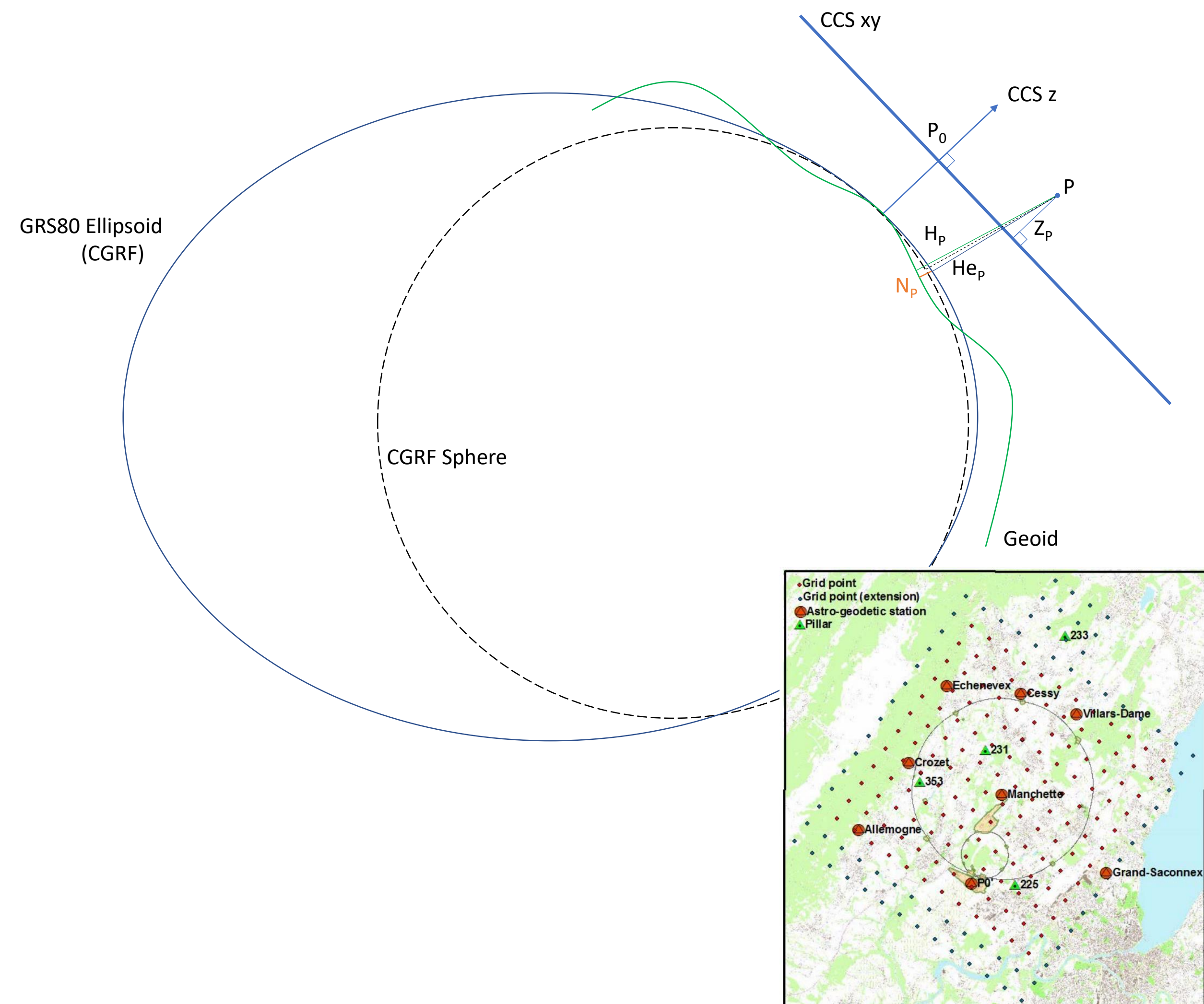
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Limits of the current geodetic infrastructure

CCS (CERN Coordinate System)

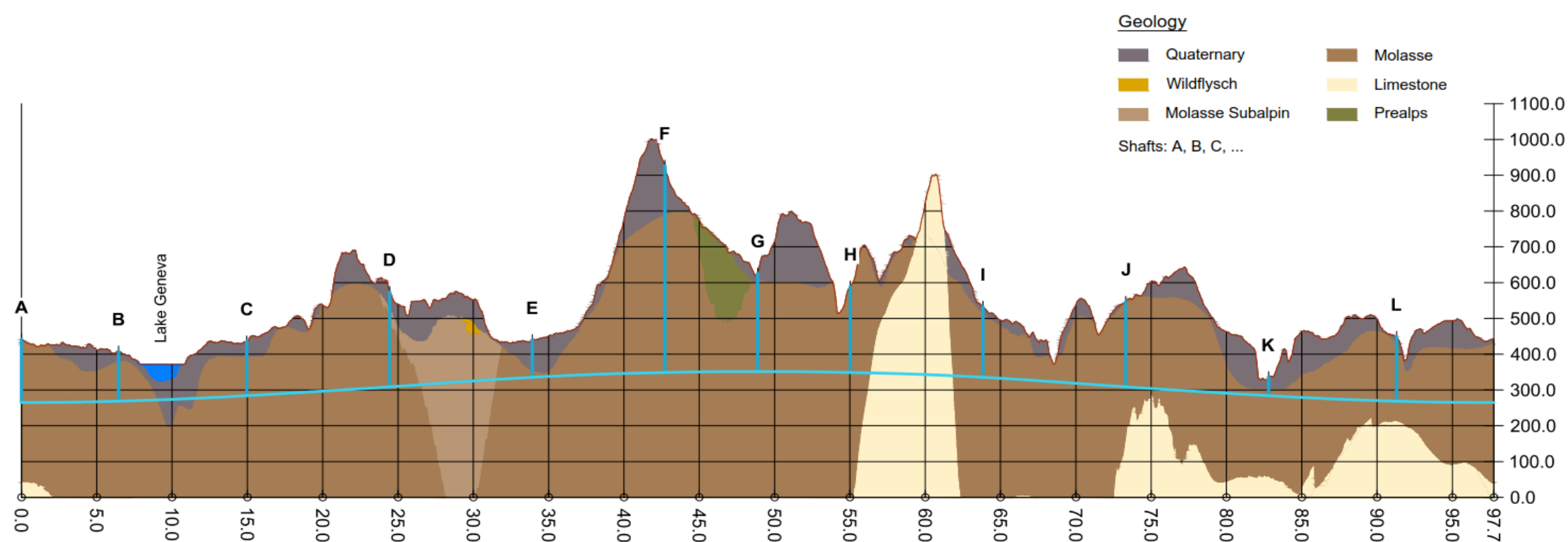
- The CCS is the reference system at CERN
- CGRF (CERN Geodetic Reference Frame) is the geodetic system associated to the CCS
- Originated from the Proton Synchrotron and has evolved with each major extension of the CERN: Super Proton Synchrotron, Large Electron-Positron Collider
- Extent limited to the current CERN area
- Adapted for local survey and alignment of the machine within the CERN but not for mapping and civil engineering works
- Need to be updated to be in line with current best geodetic practices



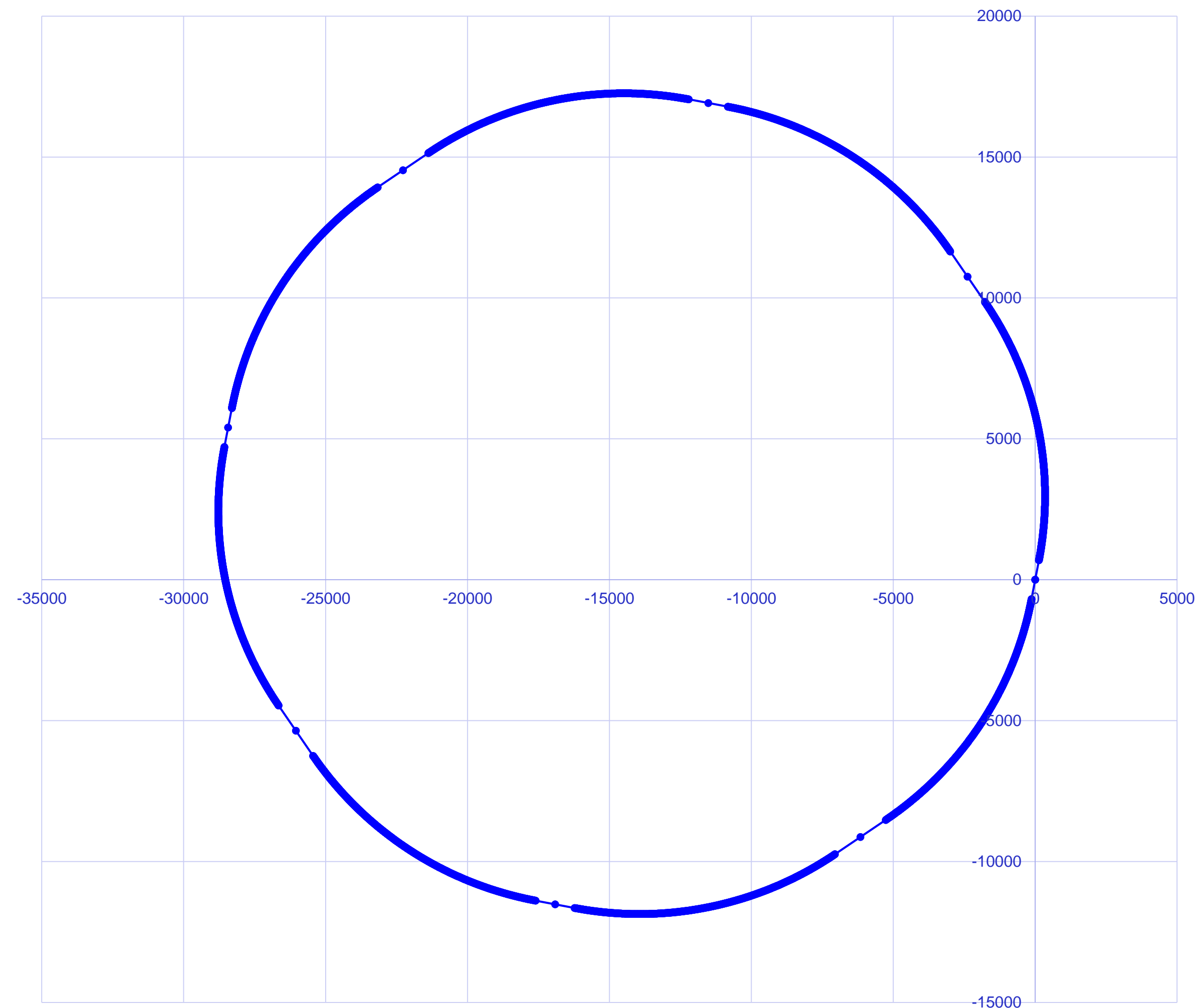
From MAD-X to real world

MAD-X

- Generate the optimal beam trajectory of the FCC
- Generate a 3D positioning of all the beam components
- Coordinates of the beam components are expressed in an arbitrary system



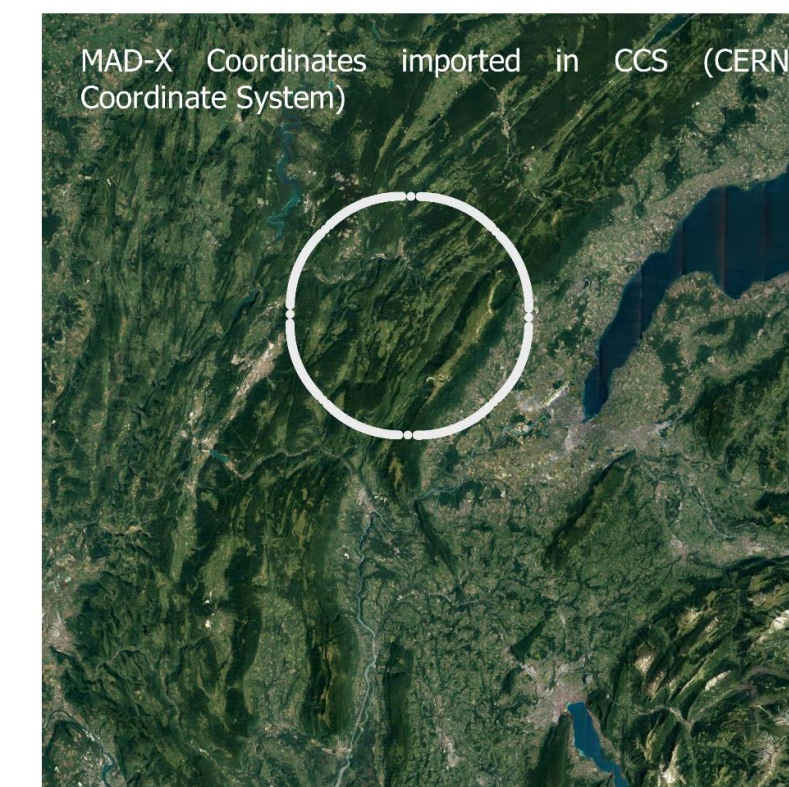
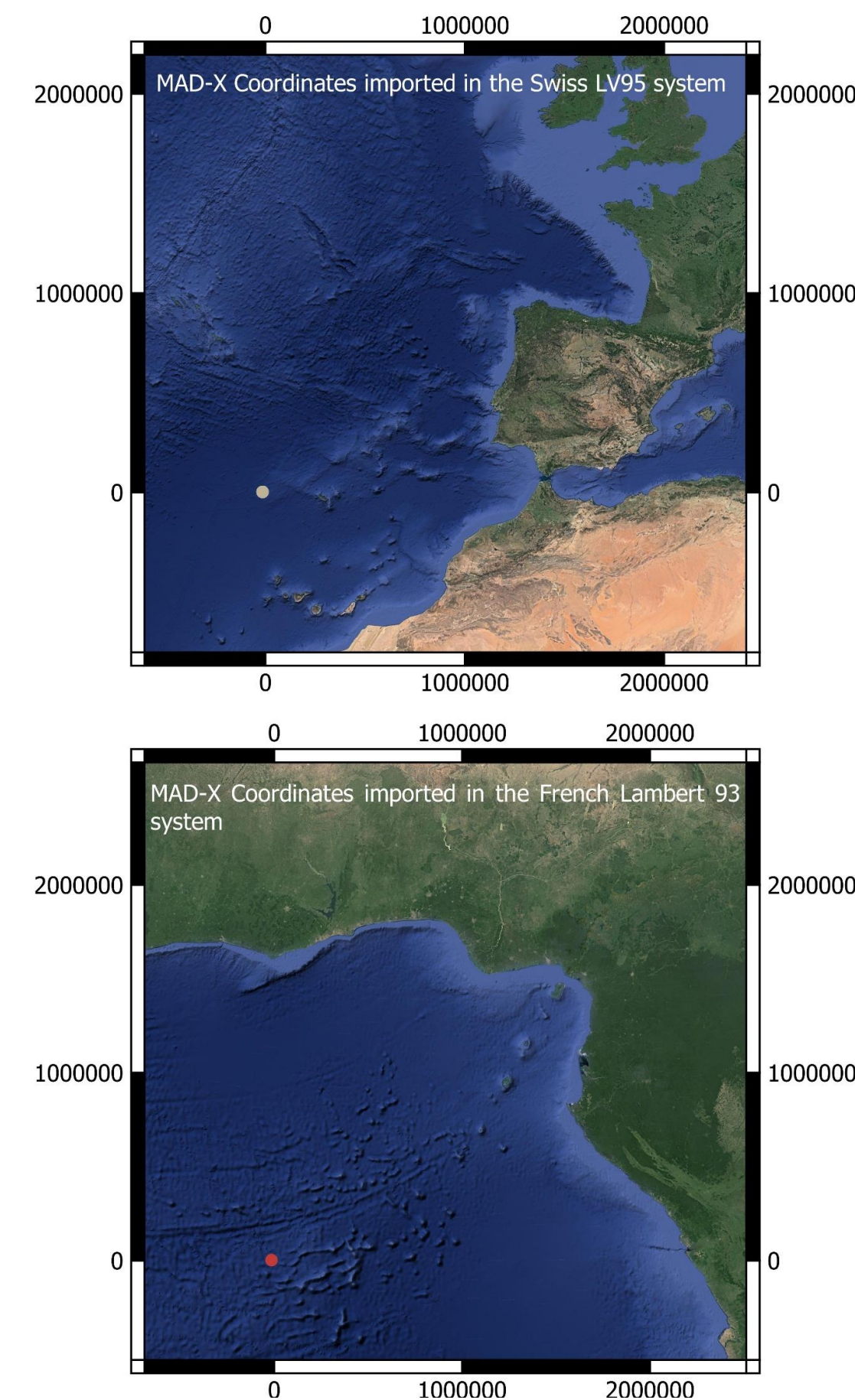
MAD-X trajectory of the FCC



From MAD-X to real world

MAD-X

- These coordinates are not sufficient to position the FCC in the real world
- There is no chance to build the FCC tunnel where it is expected using raw MAD-X coordinates
- Each projection distorts the reality and may introduce scale factor. Shifting and rotating the coordinates by a chosen value is not a valid option



From MAD-X to real world

Topocentric to geographic coordinates

- The MAD-X coordinates can be converted into geocentric coordinates, knowing the position of one initial point and initial azimuth
- The plane in which the trajectory is computed is considered tangent to the ellipsoid
- Latitude, longitude and ellipsoidal heights of all points can then be computed
- If the tunnel is bored following a defined slope to stay into specific geological layers, coordinates can be transformed into the tangential plane

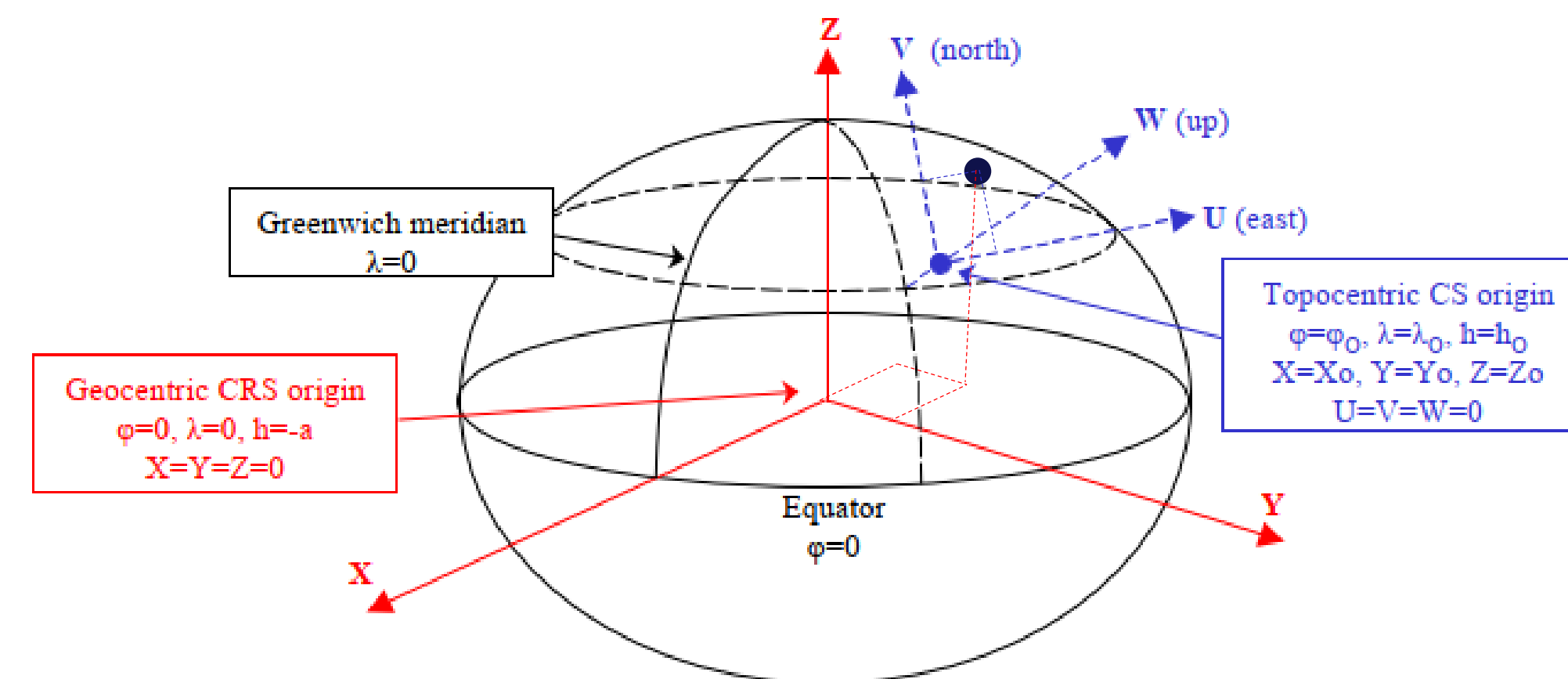


Figure 12 – Topocentric and geocentric systems

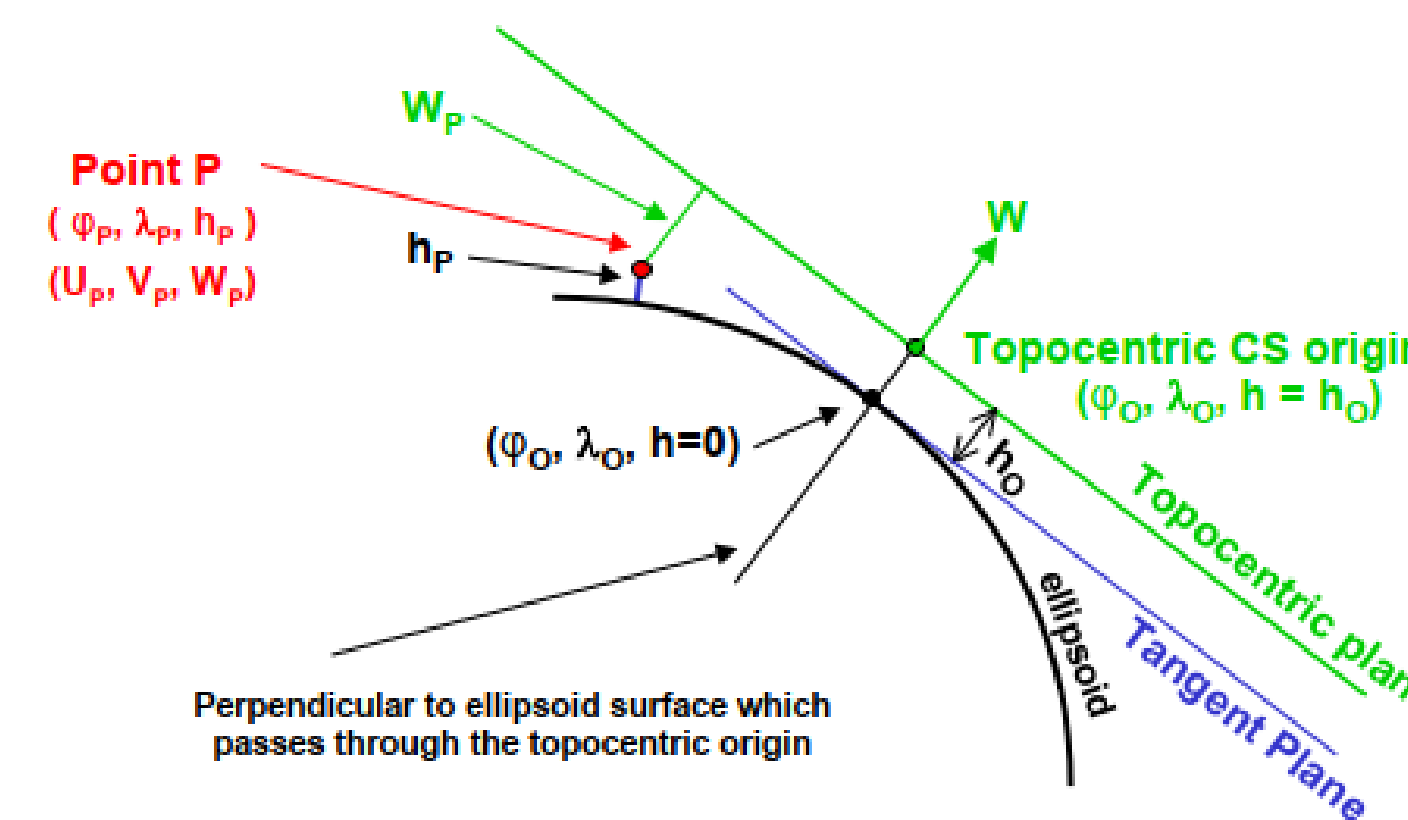
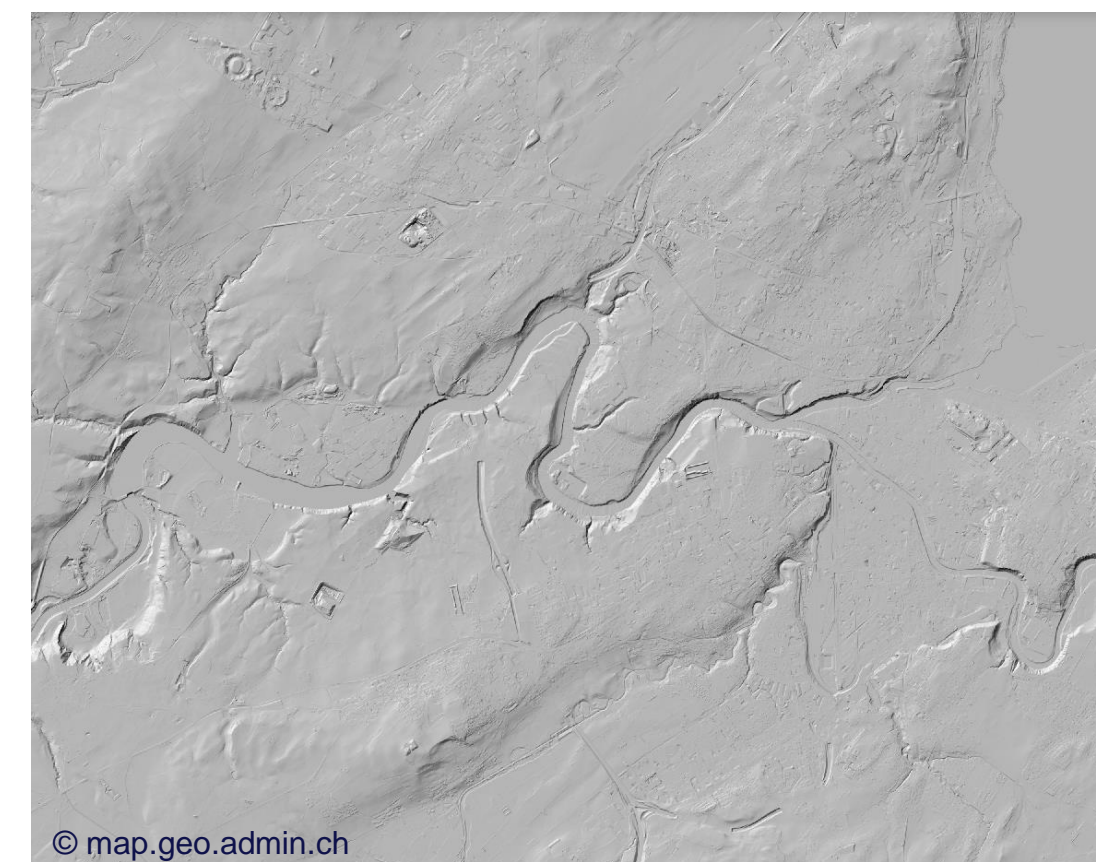
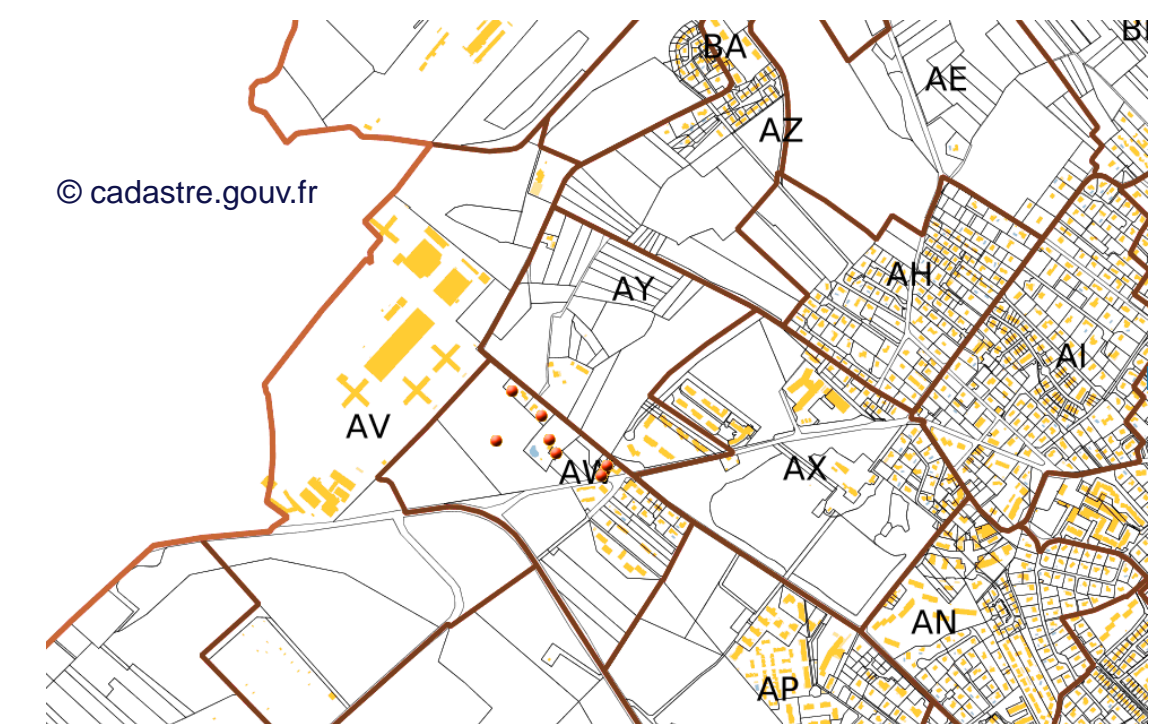
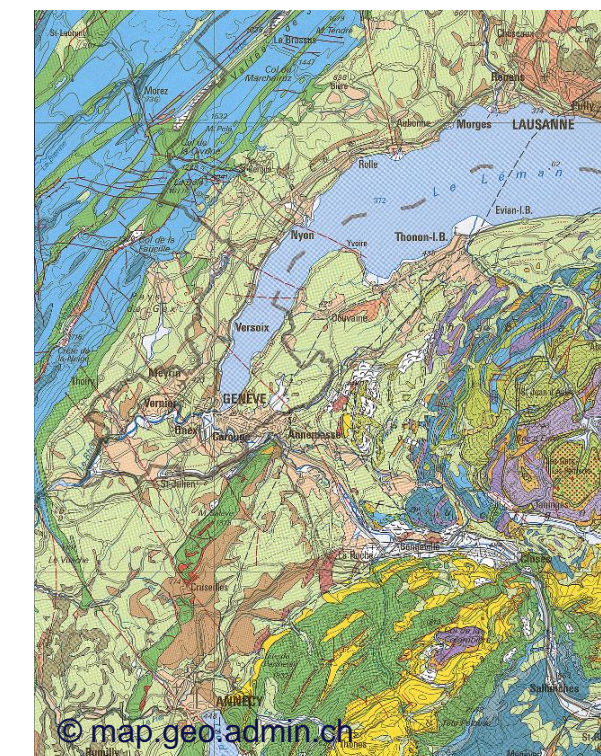
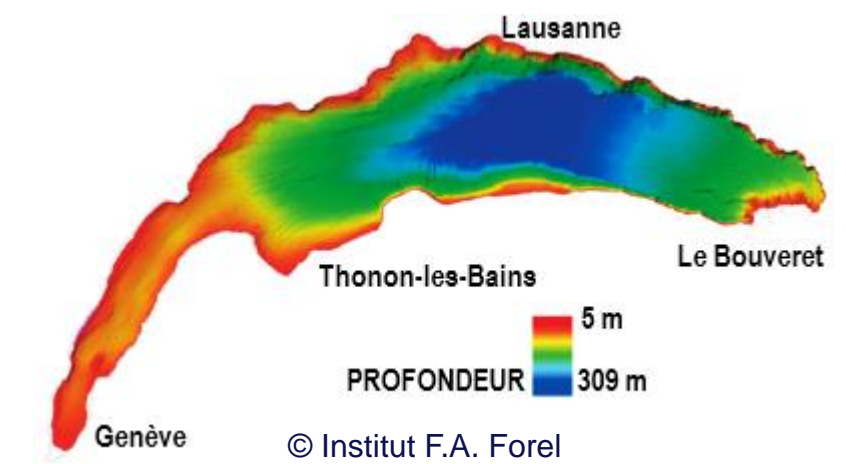
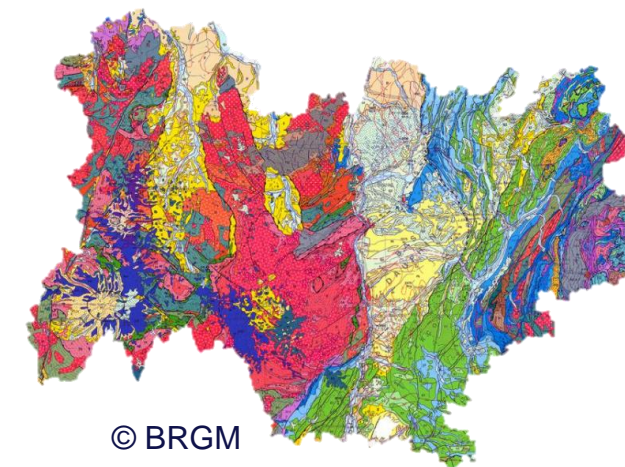


Figure 13 – Topocentric and ellipsoidal heights

Geodesy and GIS

Geographic Information System

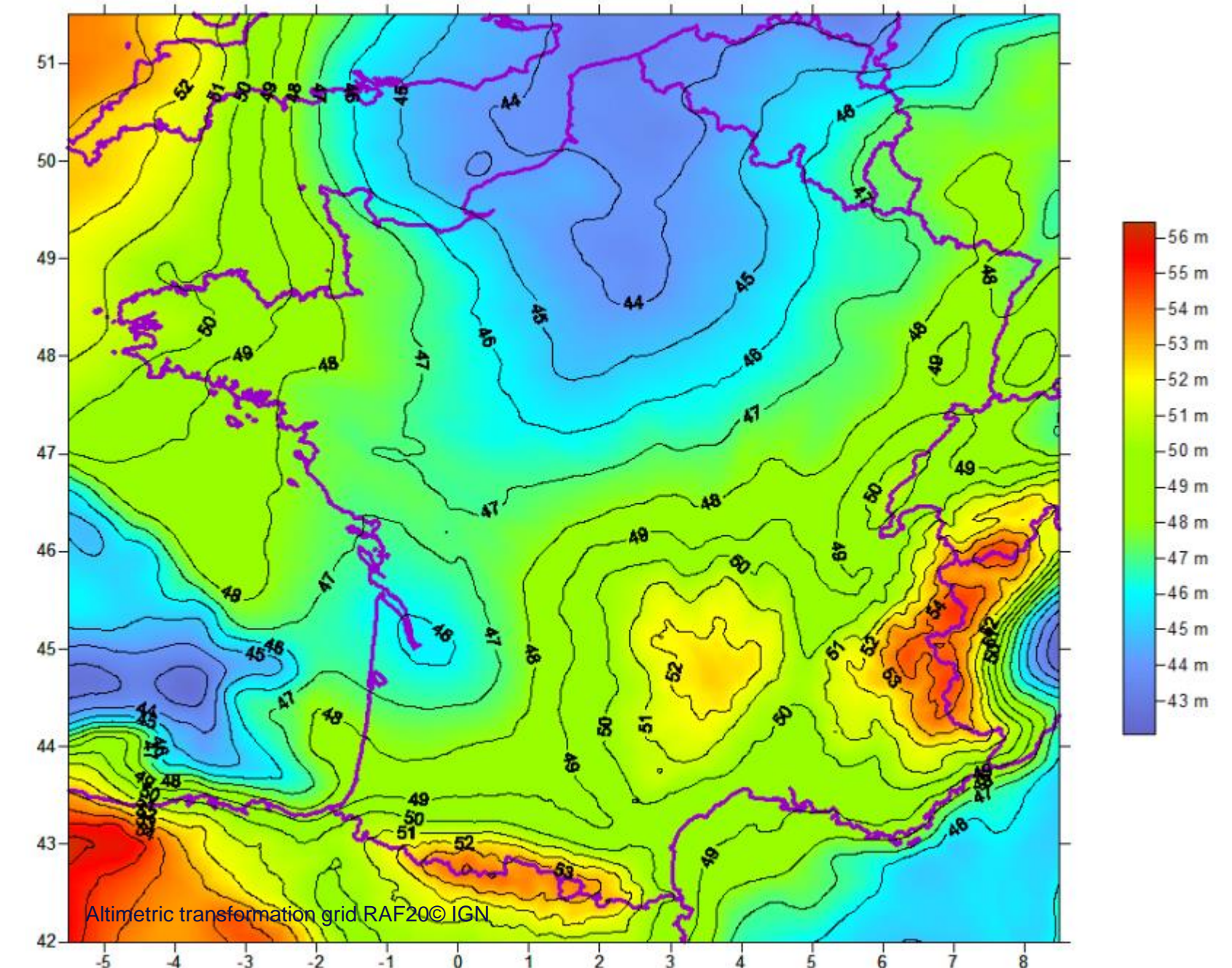
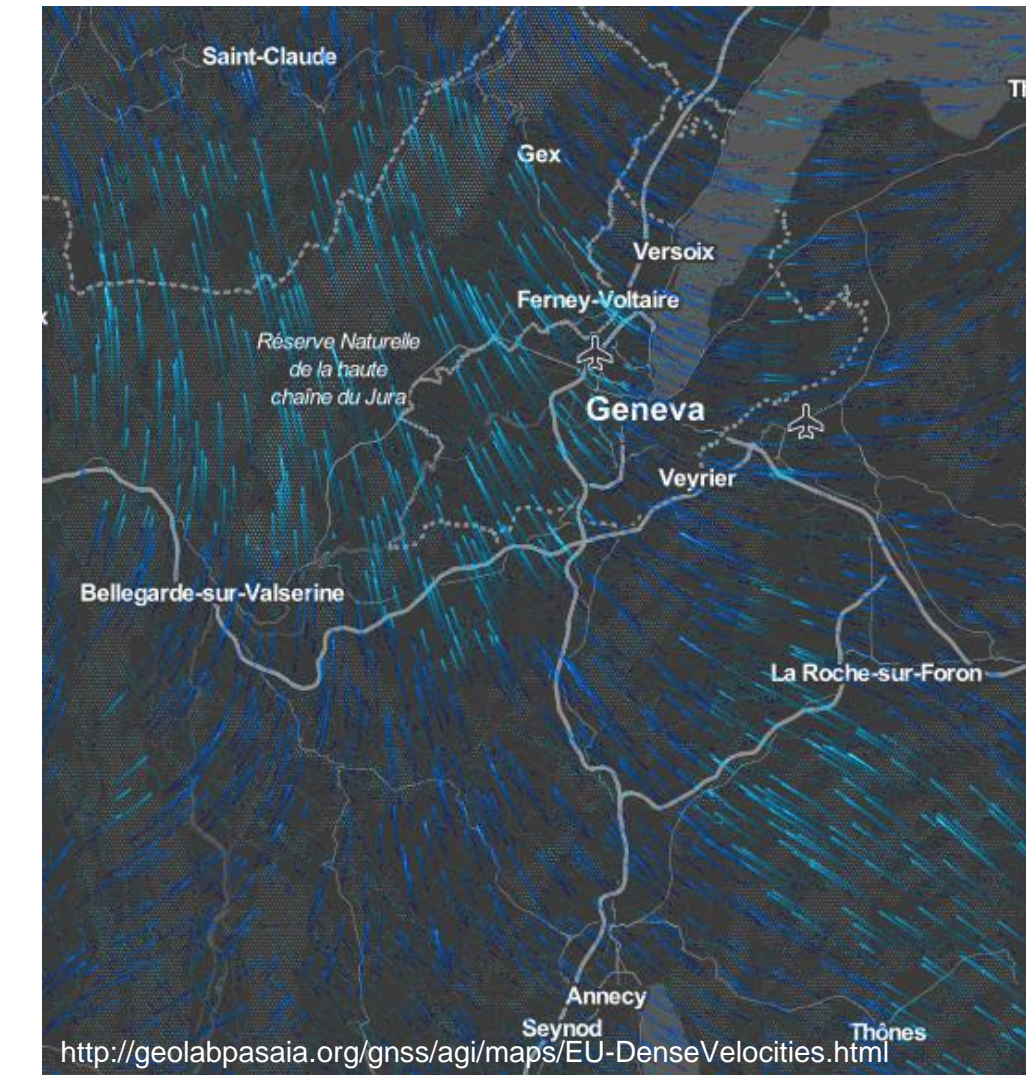
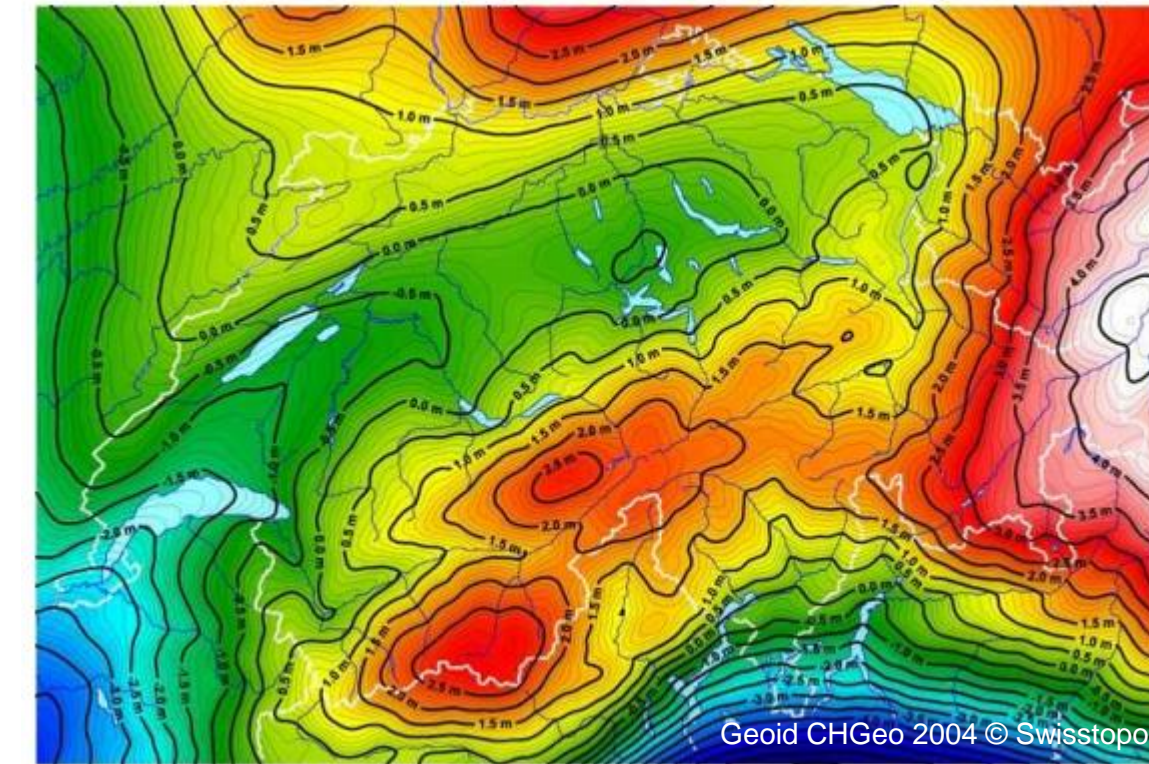
- GIS developed and maintained by the SCE-SAM-TG section: <https://gis.cern.ch/fcc>
- Gather existing georeferenced data from various type
 - Trajectory of the FCC
 - Geological models
 - Digital terrain and bathymetric models
 - Cadastre
 - Orthophotographies
 - Roads
- Coordinate systems:
 - WGS84, RGF93, CHTRF93, NTF, CH1903, CCS...
- Will integrate new data
- Need to unify all data and to be able to transform data in a specific system for the different stakeholders



Geodesy and GIS

CSGeo DLL

- CSGeo is the in-house CERN geodetic transformation software developed by the BE-GM-APC section
- Update of coordinate system definitions and transformation models
- Complete management of the French and Swiss altimetric system (~30 cm of difference observed in the CERN area)
- A Dynamic Link Library (DLL) is provided to call transformation functions from external program
 - Avoid to use external applications like Reframe or Circe



Geodesy and GIS

Note on the accuracy of the transformation

- Each dataset has its own precision and accuracy
- Each transformation model has his own accuracy and area of validity
- Applying necessary transformations do not guarantee a perfectly homogeneous and consistent results



Ortophoto of the CERN Building 2002 from two different datasources

Conclusion

Summary

- Geodetic methods, tools and software are developed to respond to the needs of the different parties taking part in the FCC feasibility studies.
- Geodesy support the FCC feasibility study to ensure a correct positioning of the tunnel and the machine

Ongoing and future activities

- The CERN geodetic infrastructure will now be updated
 - Definition and parametrization of the coordinate system dedicated to the FCC
 - Realization of a first order geodetic network
 - Implementation of a kinematic model
 - Computation of a new geoid model



Thank you for your attention