# **GNSS Products Made in Switzerland**

Rolf Dach, Stefan Schaer, Daniel Arnold, Elmar Brockmann, Maciej Kalarus, Lars Prange, Pascal Stebler, Adrian Jäggi

Astronomical Institute, University of Bern, Switzerland

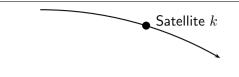
21<sup>st</sup> Swiss Geoscience Meeting 2023 17–18. November 2023, Mendrisio, Switzerland



#### **GNSS Products Made in Switzerland**

IGS: International GNSS Service

CODE: Center for Orbit Determination in Europe



Not in scale!

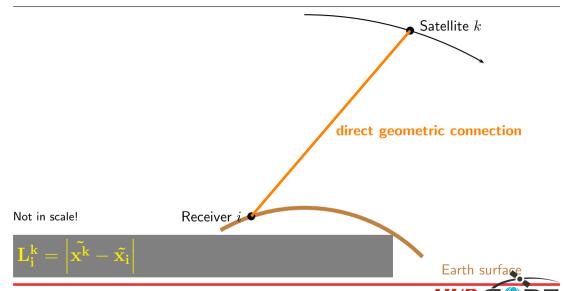




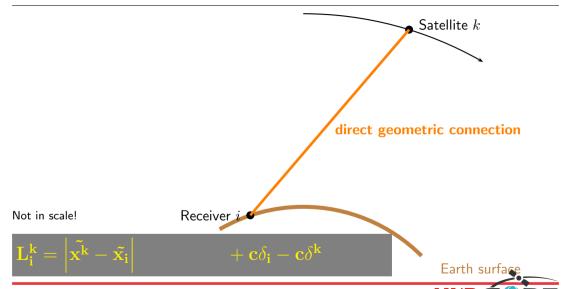
Not in scale!

Receiver i

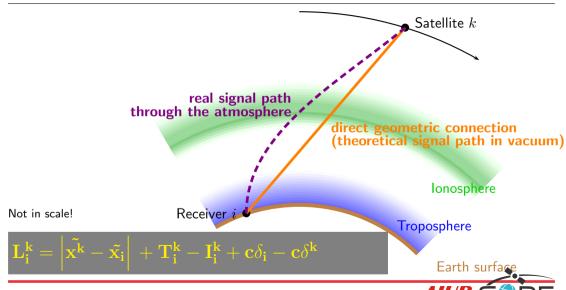




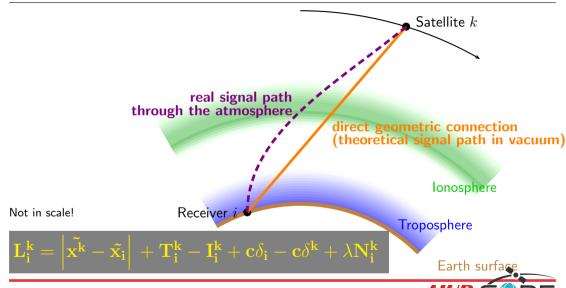
and CODE AC team: GNSS Products Made in Switzerland A 2023; 17–18. November 2023, Mendrisio, Switzerland



ı and CODE AC team: GNSS Products Made in Switzeri M 2023; 17–18. November 2023, Mendrisio, Switzerland

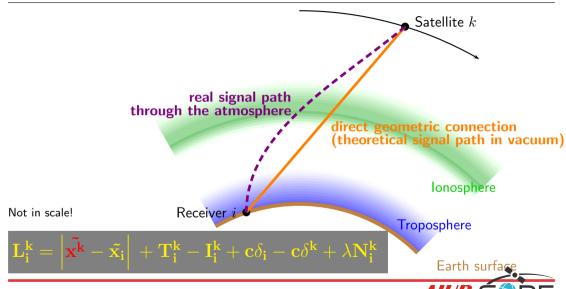


Dach and CODE AC ream: GNSS Products Made in Switzer SGM 2023; 17–18. November 2023, Mendrisio, Switzerlan

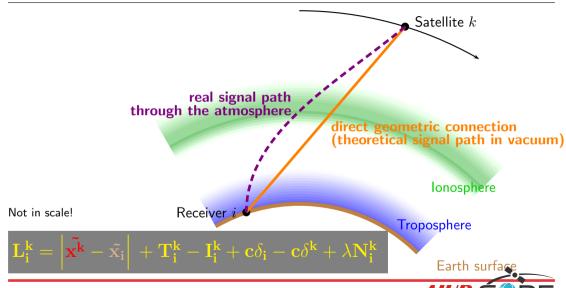


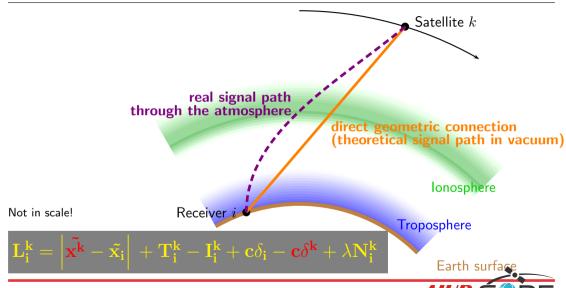
ach and CODE AC team: GNSS Products Made in Switze SGM 2023; 17–18. November 2023, Mendrisio, Switzerlan

Slide 3 of 16



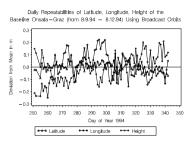
ach and CODE AC team: GNSS Products Made in Switzer SGM 2023; 17–18. November 2023, Mendrisio, Switzerland



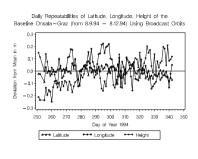


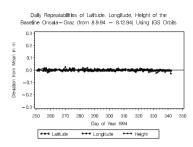
ich and CODE AC team: GNSS Products Made in Switzei GM 2023; 17–18. November 2023, Mendrisio, Switzerlan

Slide 3 of 16



 Repeatability (north, east, up) when processing 90 days of GPS observations at Graz (Austria) and Onsala (Sweden) (1200 km baseline) with broadcast orbits





- Repeatability (north, east, up) when processing 90 days of GPS observations at Graz (Austria) and Onsala (Sweden) (1200 km baseline) with broadcast orbits (left) and with IGS orbits (right).
- Towards the end of the 1980ties it was recognized that the error of the broadcast orbit was the accuracy limiting factor.

### **IGS**: First steps



# IGS: International GPS Service for Geodesy and Geodynamics

Planning phase 1989 and 1991 initiated by Ivan I. Mueller,



- Planning phase 1989 and 1991 initiated by Ivan I. Mueller,
- IGS stations  $\Rightarrow$  data centers  $\Rightarrow$  analysis centers



- Planning phase 1989 and 1991 initiated by Ivan I. Mueller,
- IGS stations ⇒ data centers ⇒ analysis centers
- First test campaign in Summer 1992



- Planning phase 1989 and 1991 initiated by Ivan I. Mueller,
- IGS stations ⇒ data centers ⇒ analysis centers
- First test campaign in Summer 1992
- Since 01. January 1994 operational service of the IAG



- Planning phase 1989 and 1991 initiated by Ivan I. Mueller,
- IGS stations ⇒ data centers ⇒ analysis centers ⇒ product combination
- First test campaign in Summer 1992
- Since 01. January 1994 operational service of the IAG
- Regular comparison and combination of the AC contributions



 International GPS Service for Geodesy and Geodynamics January 1994



- International GPS Service for Geodesy and Geodynamics January 1994
- International GPS Service May 1998

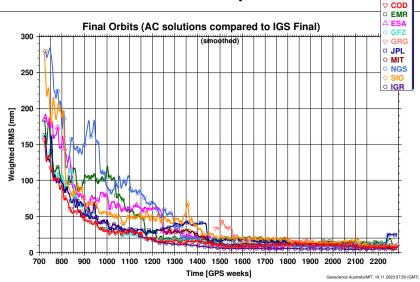


- International GPS Service for Geodesy and Geodynamics January 1994
- International GPS Service May 1998
- International GNSS Service March 2005



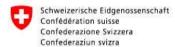


- International GPS Service for Geodesy and Geodynamics January 1994
- International GPS Service May 1998
- International GNSS Service March 2005



- CODE, Center for Orbit Determination in Europe, is one of at present ten Analysis Centers of the IGS. CODE is formed as a joint venture of
  - the Astronomisches Institut, Universität Bern (AIUB),
  - the Bundesamt f
    ür Landestopografie (swisstopo),
  - the Bundesamt für Kartographie und Geodäsie (BKG), and
  - the Institut f
     ür Astronomische und Physikalische Geodäsie of TU M
     ünchen (IAPG, TUM).



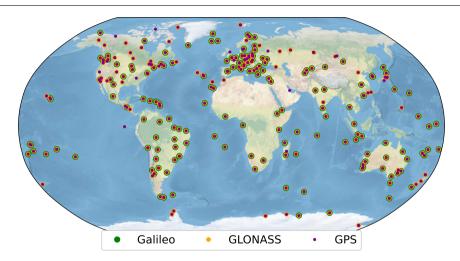




Technische Universität München



# The CODE Analysis Center

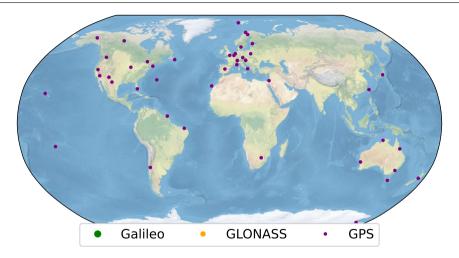


Network of about 250 stations used for the GNSS processing at CODE. Status: November 2023





# The CODE Analysis Center

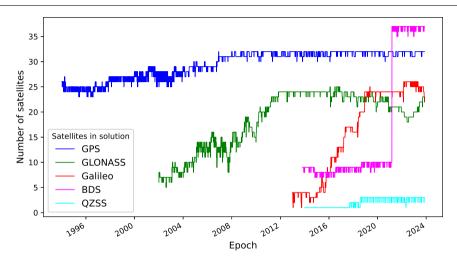


Network of about 50 stations used for the GNSS processing at CODE. Status: January 1994





#### **CODE GNSS Satellite Orbits**



Number of satellites provided by CODE in its final/MGEX orbit



#### **CODE GNSS Satellite Orbits**

























# **CODE GNSS Satellite Orbits** △ COD **GALILEO Orbits combined from all available products** o GFZ (AC solutions compared to IGS combination) (smoothed) Dashed lines are unweighted (for comparison only) ♦ IAM ♦ SHM △ WUM 40 Weighted RMS [mm] 20 10

2190

2200

2210

2180

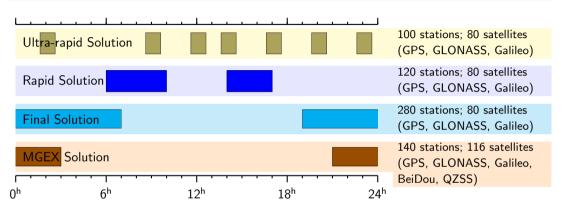
Time [GPS weeks]

2150

2160

2170

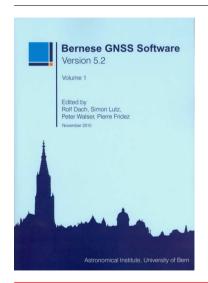
## **CODE** Processing for the IGS



IGS-related processes running at CODE analysis center



#### The Bernese GNSS Software



All processing at CODE analysis center are based on the Bernese GNSS Software package, developed at AIUB.

Communic GMSS Sufficient Notices 52 – D X	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
GPSEST 3.1: General Options 1	
TITLE FHX2SHX_SYSS+O_S(FFFF): QIF ambiguity resolution	
OBSERVATION SELECTION	FFE Server INNX2SPACECE 7 X
Satellite system ALL Frequency/linear combination L14L2 Elevation cutoff angle 10 degrees	Status of RMX28NX.PCF at 08-Jul-2021 20:07:03
sampling interval 10 seconds Tolerance for simultaneity 100 milliseconds Special data selection 100 milliseconds Observation window NO TORT-THE	Session 102070; running
OBSERVATION MCDELIMS AND PARAMETER ESTIMATION A priori signs of unit weight Elevation-dependent weighting Type of computed residuals Correlation strategy MARLING	OO4 COOVEL RES_GRE2 running < 005 CRIMERED RES_GRE2 waiting < 015 CRIMERED RES_GRE2 waiting < 021 OBBEFORD RES_GRE2 waiting < 022 OBBEFORD RES_GRE2 waiting < 022 OBBEFORD RES_GRE2 waiting < 031 ION_HOG RES_GRE2 waiting < 031 ION_HOG RES_GRE2 waiting < 032 OBBEFORD RES_GRE2 waiting < 034 OBBEFORD RES_GRE2 waiting < 035 OBBEFORD RES_GRE2 waiting < 036 OBBEFORD RES_GRE2 waiting < 037 OBBEFORD RES_GRE2 waiting < 038 OBBEFORD RES_GRE2 waiting < 039 OBBEFORD RES_GRE2 waiting <
LEC-SPECIFIC SELECTION AND MODELING OPTIONS Elevation cutoff angle	111 ORINHORN R2S_CEN running < 112 PRETAR R2S_CEN waiting 113 ORBORNH R2S_CEN waiting 199 DUNHY NO OPP waiting 201 HMKSMYAP R2S_CEN waiting 202 HMKSMYAP R2S_CEN waiting 202 HMKSMYAP R2S_CEN waiting
ATOP Prev Next Cance'l Save'As 'Save Run 'Coppt Refor A-Day A-Day	211 RNXGRA R2S_GEN waiting



IGS: Family: 350 institutions from 188 countries





IGS: Family: learn more at www.igs.org





Acknowledge their work by referencing





Join the IGS family – we are open

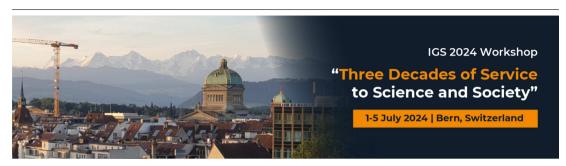




# IGS 2024 Workshop

Join the IGS family - we are open





# IGS 2024 Workshop

Join the IGS family – we are open

We are looking for supporting staff (contact rolf.dach@unibe.ch or your supervisor)



# **THANK YOU**

# for your attention

