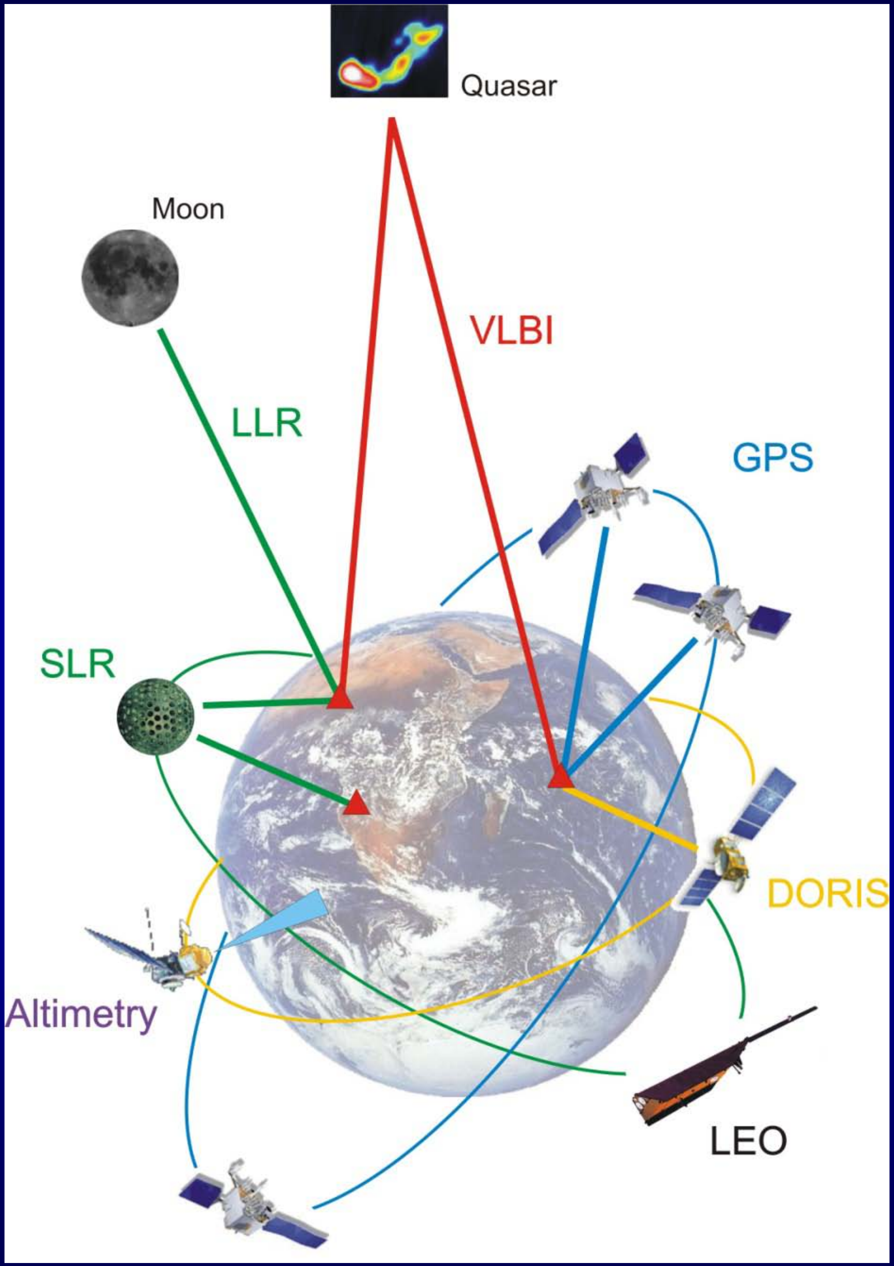

Unified Analysis Workshop 2009

Overview of UAW Goals

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Unified Analysis Workshop 2009
December 11-12, 2009
San Francisco, CA

Unified Analysis Workshop 2009: Scope and Goals

- Involve **the experts** from GGOS, IERS, IGS, IVS, ILRS, IDS and IGFS
- Increase the **common understanding** of all techniques for each individual technique as they contribute to a GGOS
- Make **concrete progress** on (i.e. action items, deadlines):
  - Setup of meta data standards (format) and data flow
  - Handling of technique-specific systematic biases
  - Importance / problems of corrections based on external data
  - Improved strategies for the combination of the different techniques and parameters
  - Common standards for an extended parameterization
  - Work on new combined products to be realized in the next few years
  - Design / instrumentation of future GGOS core network

Structure of GGOS

The Services are GGOS

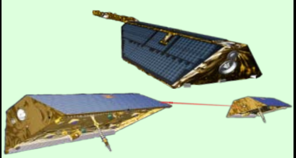
Bureau for Networks and Communication

Global Networks of Observing Stations

Regional and Global Data and Product Centers

Archiving and Dissemination

Earth Observation Satellites / Planetary Missions



Mission-specific Data and Product Centers

Archiving and Dissemination

Bureau for Satellite and Space Missions

Data Analysis Centers

Combination Centers

Modeling Centers

Bureau for Conventions and Standards

Coordination Office

GGOS Portal

Access to all information, data, products

Users Science & Society

Meta data; information

Real data; information

Characteristics of the products we are looking for

- ***Easy access to products:*** meta data for GGOS portal, meta data format and flow
- ***Consistency of products:*** Consistency of the modeling and parameterization within one technique and among different techniques
- ***Accuracy of products:*** best possible geodetic / geophysical models have to be used; reduction of biases
- ***Rigorous combination:*** combination of all parameters common to more than one technique; co-location on ground and in space:

  quasar coord., nutation, troposphere, low-degree SH, clocks, …
- ***Product Latency:*** products with different latencies (and accuracies) have to be generated

  multi-year, weekly, daily, predicted
- ***GGOS integrated products:*** combination of geometry and gravity; integrated products

  global vertical datum, mass balance, surface deformation/strain, …

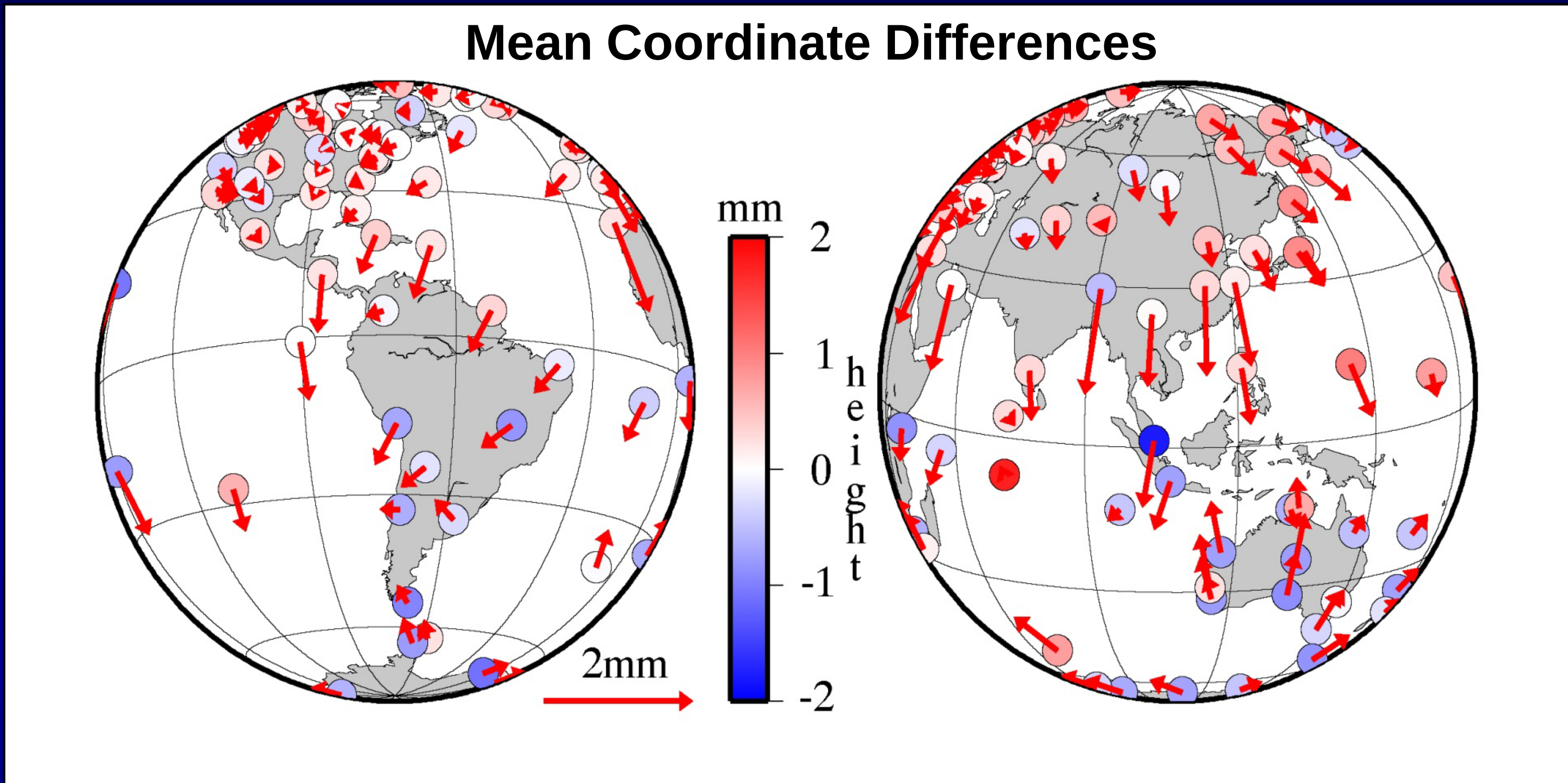
Unified Analysis Workshop 2009: Program

	Welcome and Introduction: Goals of UAW
Session 1	**Products by the Services, GGOS Portal and Metadata** *Chairs: Neilan R., Richter B., Noll C.*
Session 2	**Modeling Deficiencies and Modeling Based on External Data (Atmosphere, Ocean, ...)** *Chairs: Böhm J., van Dam T.*
Session 3	**Combination Strategies, Common Parameters and Combined Products** *Chairs: Schuh H., Biancale R., Altamimi Z.*
Session 4	**Network Simulations and Analyses** *Chair: Pearlman M., Ries J., Pavlis E.*
	Discussion, Conclusions and Action Items

Session 1: Products by the Services, GGOS Portal and Metadata

- Report the **present status** and **future ideas** of the Services
- Understand the processing details and **problems** of the individual techniques
- Information about the **improvements planned** by each of the techniques
- Discuss ways to **reduce the deficiencies** and cure problems in the future
- Define formats, data structures and data flows for **meta data** for the **GGOS Portal**
- Updated version of **SINEX format**

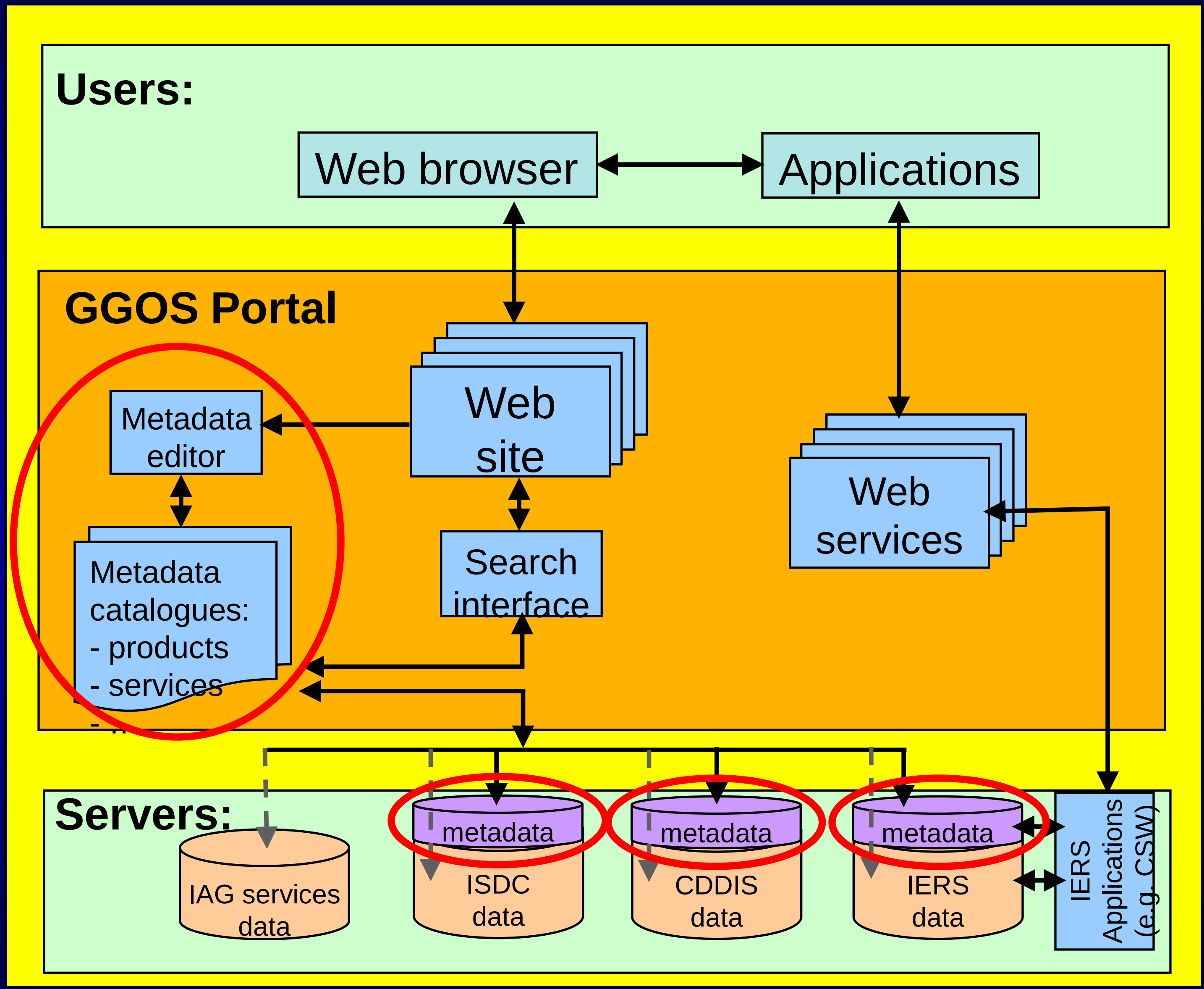
Example: Higher-Order Ionosphere Effects



Residuals of 1-year solutions with and without modeling of the 2nd- and 3rd-order ionospheric effect

Fritsche et al.: Impact of higher-order ionospheric terms on GPS estimates, GRL (2005)

GGOS Portal: Meta Data Required

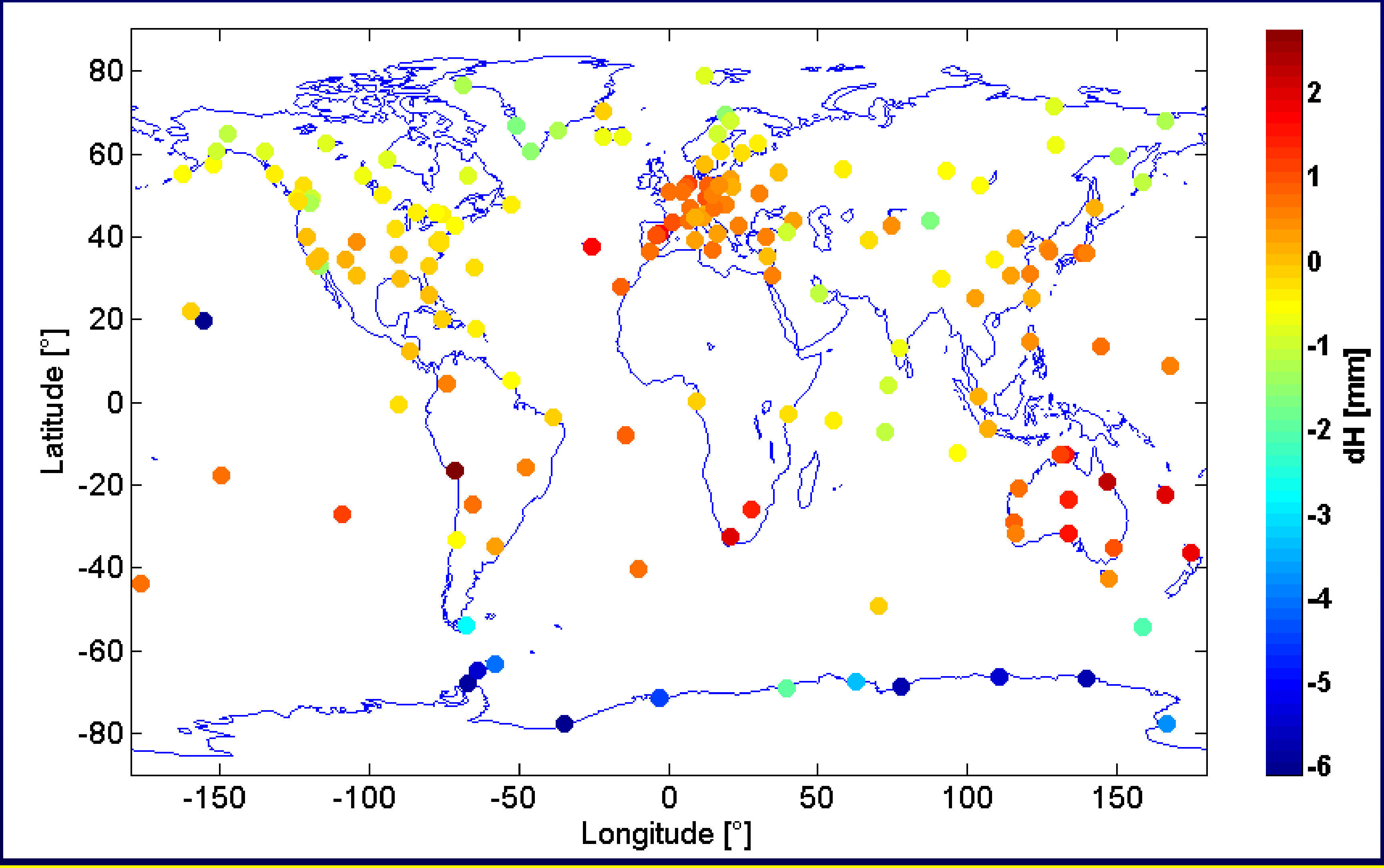


Session 2: Modeling Deficiencies and Modeling Based on External Data (Atmosphere, Ocean, ...)

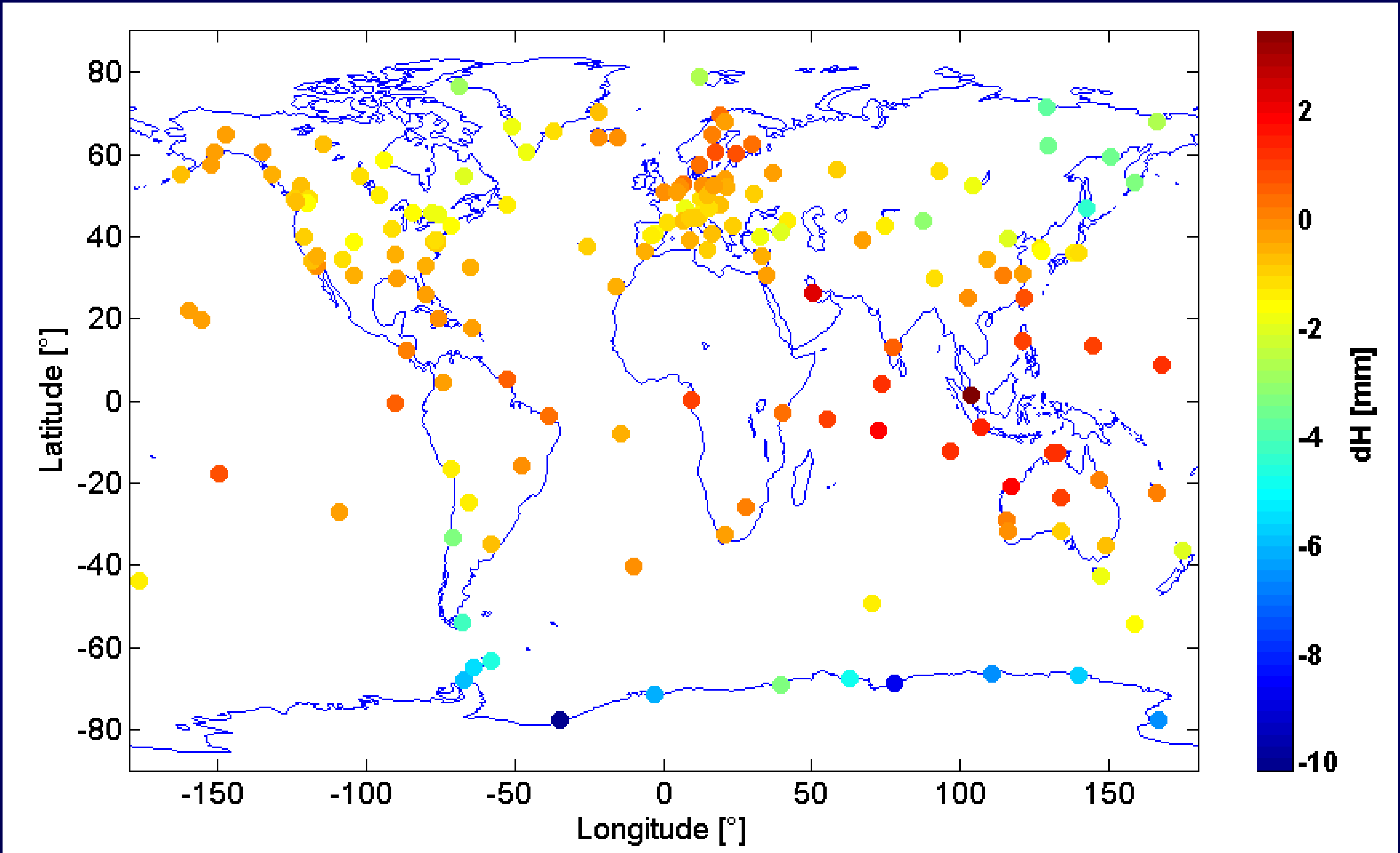
- ***Paradigm change:*** modeling of corrections more and more based on **large amounts of external data** than based on "simple" mathematical formulas
- ***Examples:***
  - Mapping functions, hydrostatic delays, troposphere gradients derived from meteorological models
  - Atmospheric, hydrological and non-tidal oceanic loading corrections based atmosphere, ocean and hydrological models
- Assess the **benefits** of correction models based on large external data sets
- Discuss the **implications** of the paradigm change, i.e. of using large amounts of external data (availablility, reliability, consistency, real-time issues, …)

Ex.1: Impact of Hydrostatic a Priori Delays

Station height differences due to different hydrostatic a priori delays: constant vs. ECMWF



Ex. 2: Station Height Differences NMF/VMF1



Session 2: Modeling Deficiencies and Modeling Based on External Data (Atmosphere, Ocean, ...)

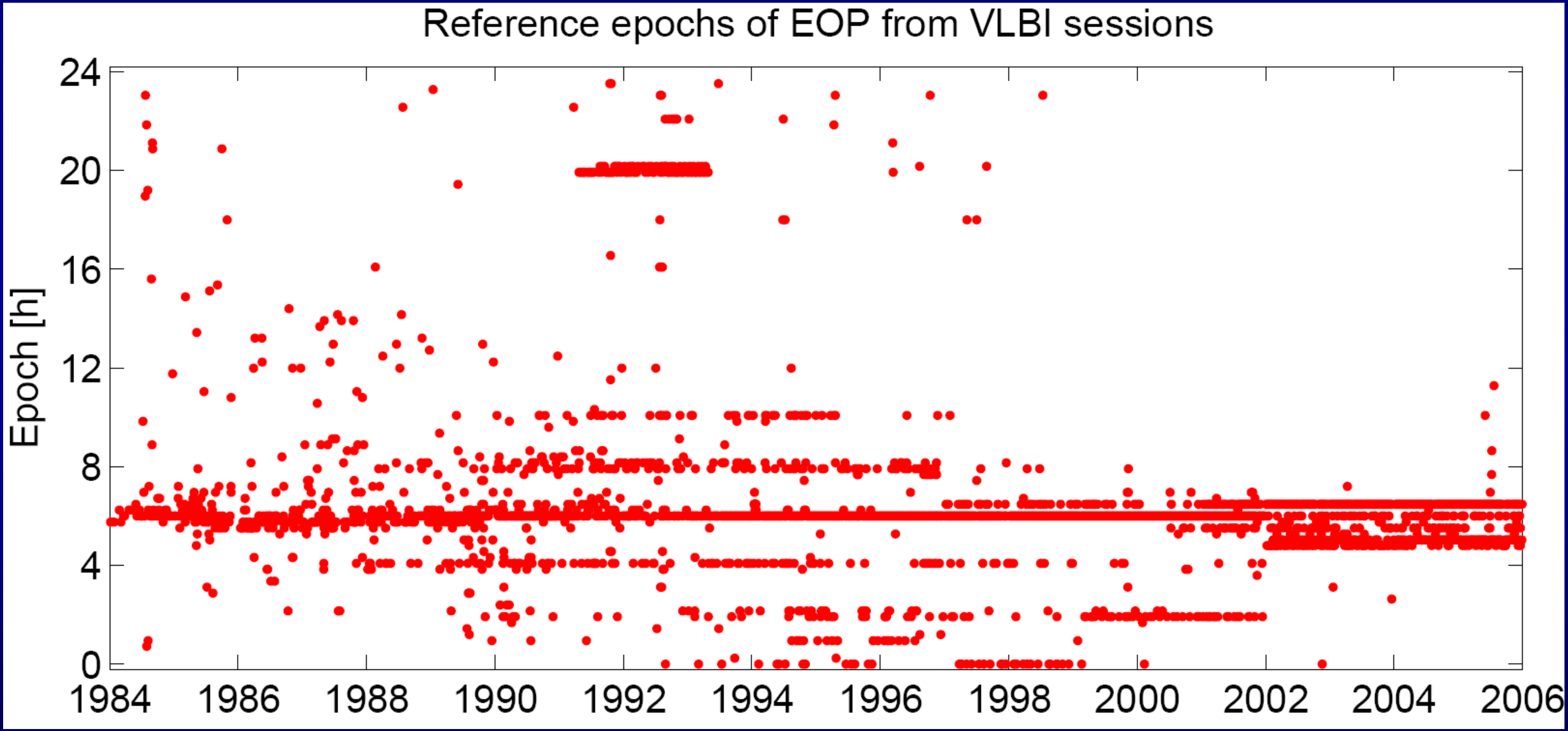
- Improve the accuracy and consistency of the **geodetic / geophysical models** used
- Reduction of **(technique-specific) biases** like
  - Antenna phase center corrections, CoM corrections
  - Range biases
  - Antenna deformation (gravitational, thermal, …)
  - Higher-order ionospheric effects

Session 3: Combination Strategies, Common Parameters and Combined Products

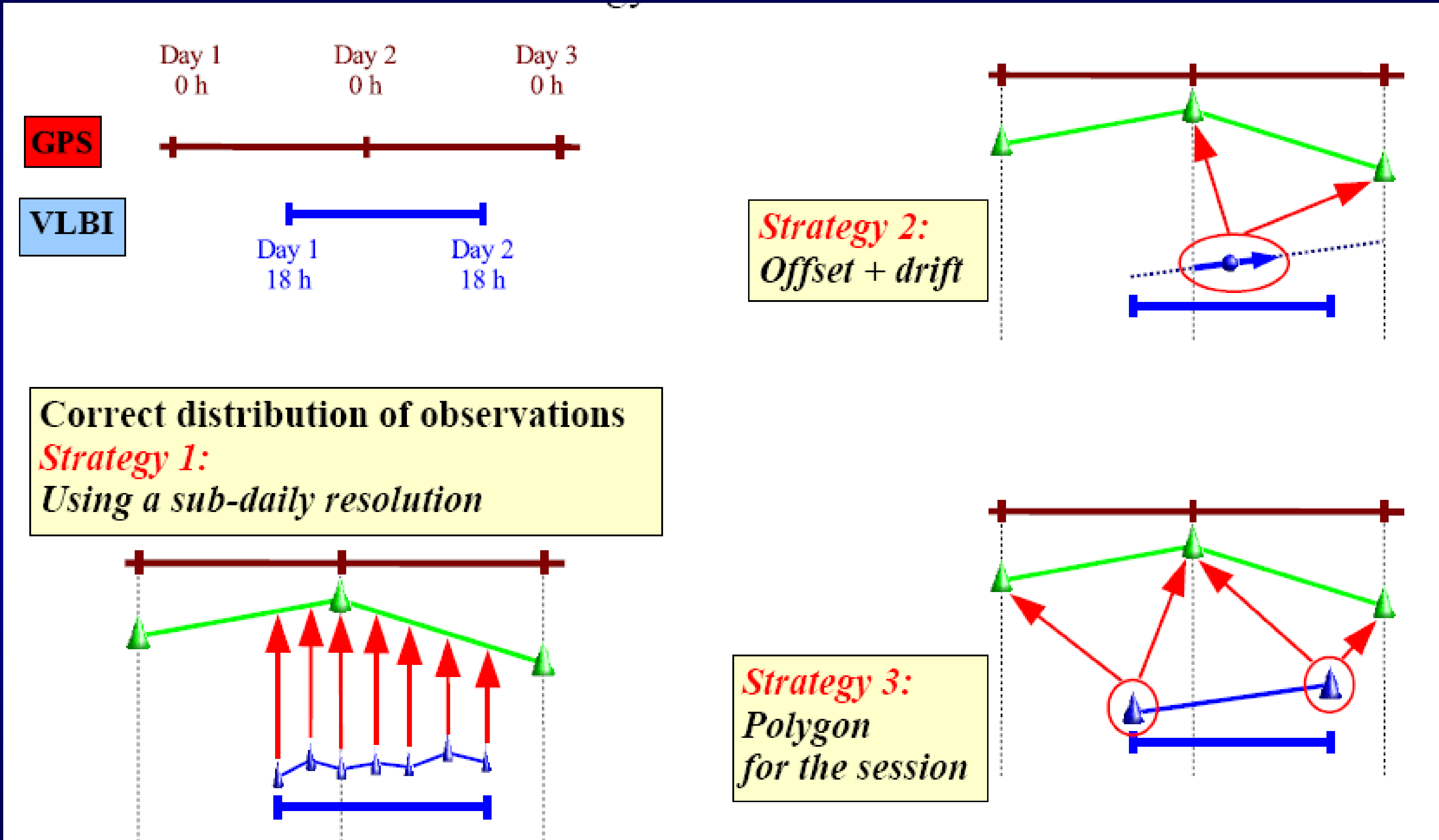
- Improve common understanding of **combination strategies**
- Understand the **singularities** and **correlations** between different parameter groups and their impact
- Concepts for **UT1/LOD** and **nutation offsets/rates** combination
- Increase **parameter space** of combination: define **parameter types to be provided in SINEX** and their unique parameterizations and time resolution
- Steps towards **new combined products** (daily, weekly combined products; troposphere; …)
- Benefits of **observation level combination**

Example: Consistency of Parameterization

VLBI sessions lasting from ~18:00 – 18:00 UTC:
→ Combination of Earth Rotation Parameters difficult



Example: Combination of ERPs from GPS and VLBI



Today: ITRF Parameter Space

Parameter space for a rigorous combination:

Parameter Type	VLBI	GPS/ GLON.	DORIS/ PRARE	SLR	LLR	Alti-metry
Quasar Coord. (ICRF)	X					
Nutation	X	(X)		(X)	X	
Polar Motion	X	X	X	X	X	
UT1	X					
Length of Day (LOD)	X	X	X	X	X	
Coord.+Veloc.(ITRF)	X	X	X	X	X	(X)
Geocenter		X	X	X		X
Gravity Field		X	X	X	(X)	X
Orbits		X	X	X	X	X
LEO Orbits		X	X	X		X
Ionosphere	X	X	X			X
Troposphere	X	X	X			X
Time/Freq.; Clocks	(X)	X		(X)		

ICRF

ITRF

Atmosphere

Earth Rotation

Gravity Field

Today: Routine Products Parameter Space

Parameter space for a rigorous combination:

Parameter Type	VLBI	GPS/ GLON.	DORIS/ PRARE	SLR	LLR	Alti-metry
Quasar Coord. (ICRF)	X					
Nutation	X	(X)		(X)	X	
Polar Motion	X	X	X	X	X	
UT1	X					
Length of Day (LOD)	X	X	X	X	X	
Coord.+Veloc.(ITRF)	X	X	X	X	X	(X)
Geocenter		X	X	X		X
Gravity Field		X	X	X	(X)	X
Orbits		X	X	X	X	X
LEO Orbits		X	X	X		X
Ionosphere	X	X	X			X
Troposphere	X	X	X			X
Time/Freq.; Clocks	(X)	X		(X)		

ICRF

ITRF

Atmosphere

Earth Rotation

Gravity Field

Vision: Future Parameter Space

Parameter space for a rigorous combination:

Parameter Type	VLBI	GPS/ GLON.	DORIS/ PRARE	SLR	LLR	Alti- metry
Quasar Coord. (ICRF)	X					
Nutation	X	(X)		(X)	X	
Polar Motion	X	X	X	X	X	
UT1	X					
Length of Day (LOD)	X	X	X	X	X	
Coord.+Veloc.(ITRF)	X	X	X	X	X	(X)
Geocenter		X	X	X		X
Gravity Field		X	X	X	(X)	X
Orbits		X	X	X	X	X
LEO Orbits		X	X	X		X
Ionosphere	X	X	X			X
Troposphere	X	X	X			X
Time/Freq.; Clocks	(X)	X		(X)		

ICRF

ITRF

Atmosphere

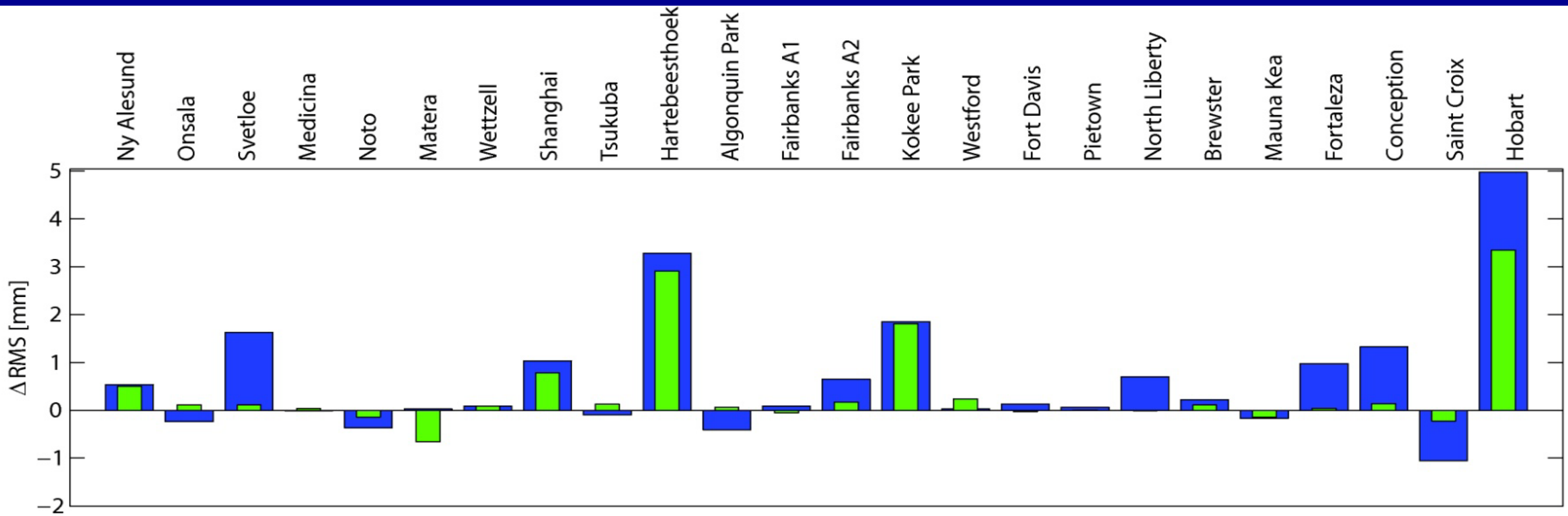
Earth Rotation

Gravity Field

Combination of Troposphere

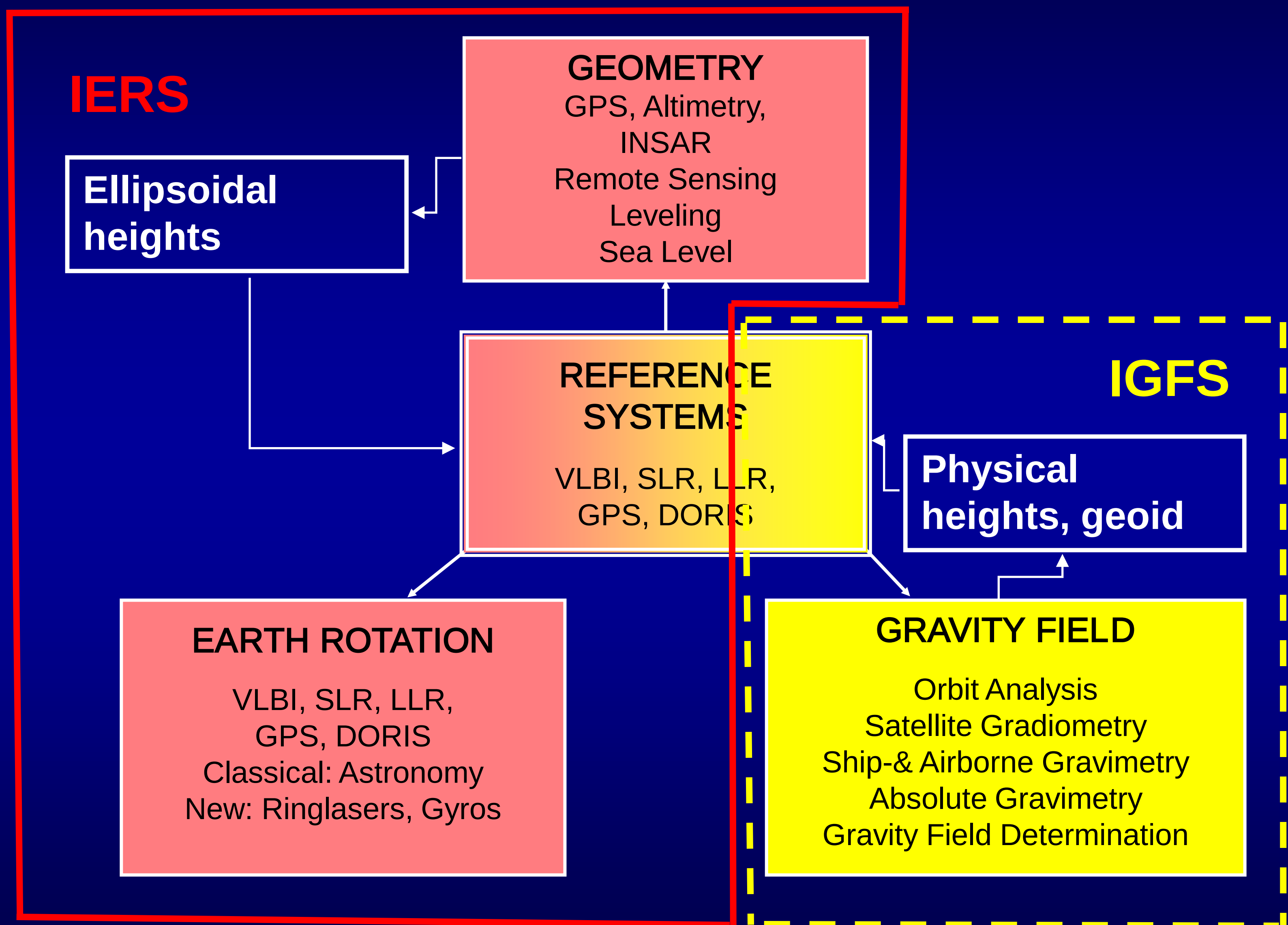
Change of the daily repeatability of VLBI station height:

- Combining zenith delay parameters (green)
- Combining zenith delay parameters and troposhere gradients (blue)

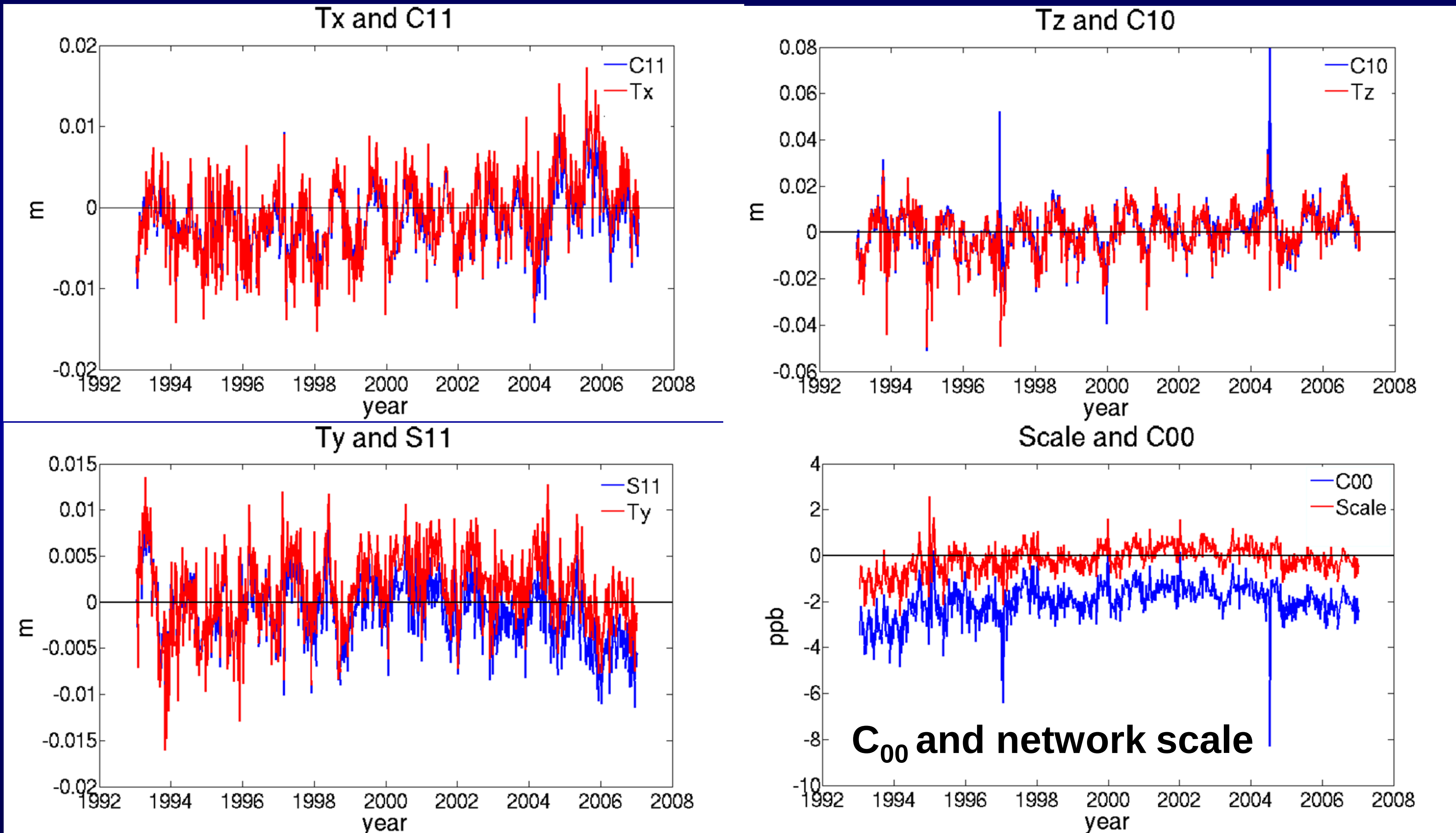


Positive sign means RMS becomes smaller

Combination of Geometry and Gravity (IERS/IGFS)



Gravity ←→Geometry: Equivalence of Degree-1 Gravity Coefficients and Geocenter



Combined Products with Different Latency

Product Type	Main Parameters	Generation Cycle	Maximum Latency	Based on
Multi-Year	ITRF, EOPs, ICRF, static gravity field; time series of para-meters (site coo. etc.)	Yearly	~ 1 year	Reprocessed high-accuracy time series from each technique
Weekly “Final”	EOPs, site coord-inates, gravity field variations, …	Weekly	3 weeks	Based on the “final” routine intra-technique com-bined products
Daily “Rapid”	EOPs, site coord-inates, tropospheric delays, etc.	Daily	1 day	VLBI Intensives and IGS Rapids and SLR/DORIS
Daily ”Predicted”	EOPs, …	Daily	1 day	Combined daily rapid IERS products

Session 4: Network Simulations and Analyses

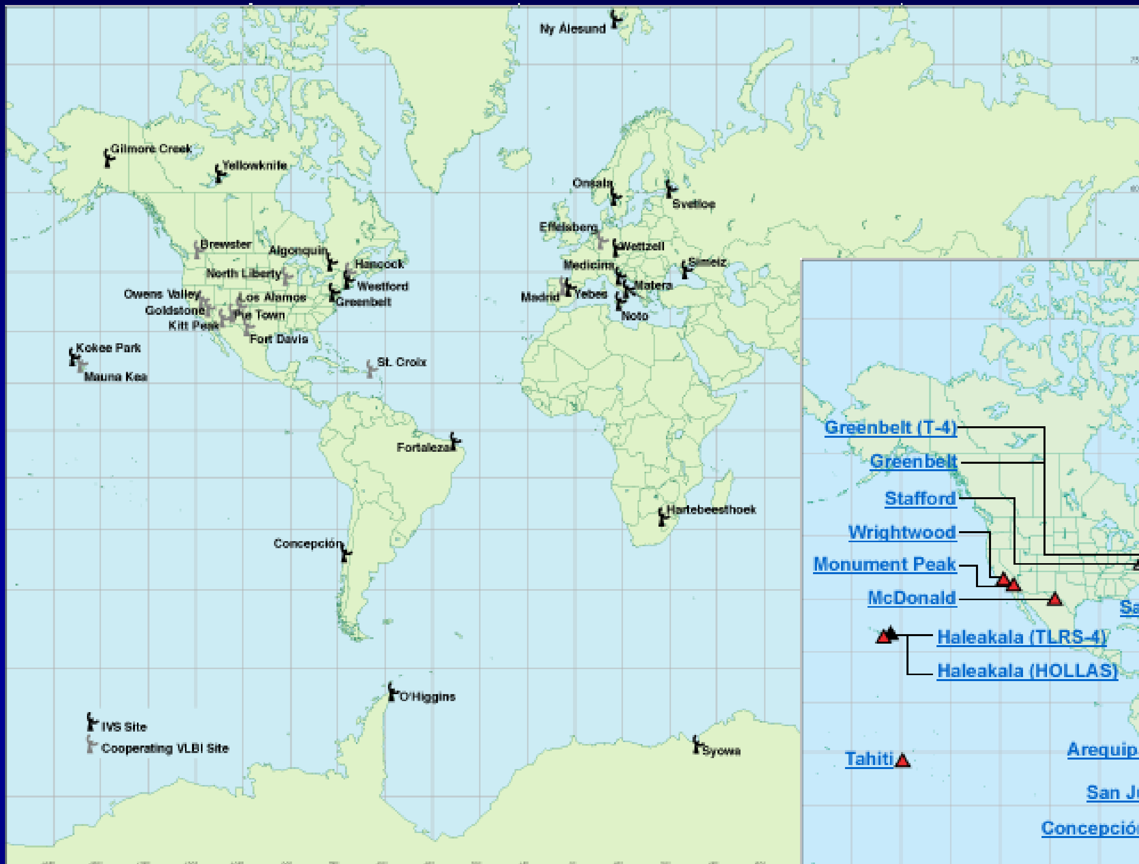
- Assess **network characteristics** required to fulfill demanding requirements (e.g., 1 mm reference frame, 0.1 mm/y stability)

- Identify improvements to be achieved with **technological innovations** (technique-specific and local ties)

- What **instrumentation** should be present at a GGOS core site ? What is mandatory, what is optional ?

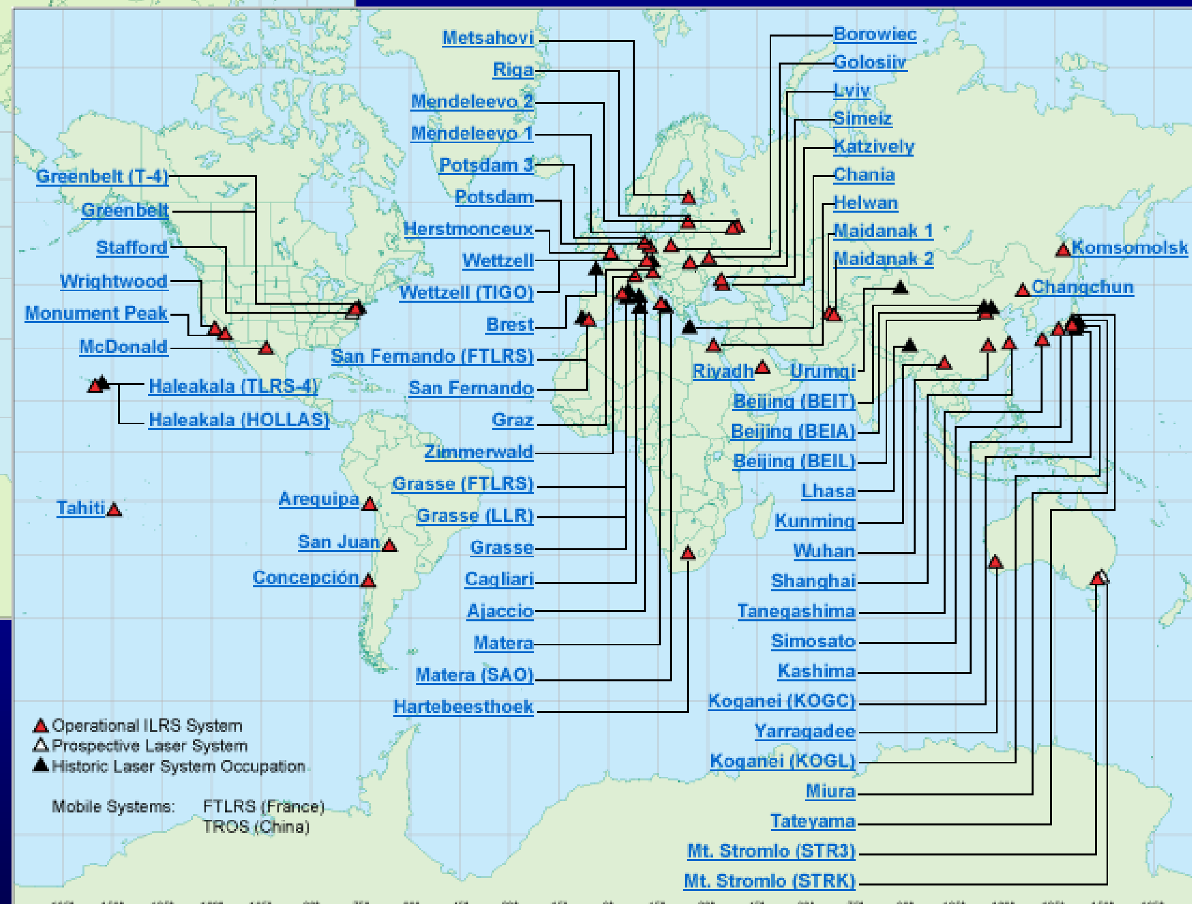
Bodengestützte Komponente: Netze

Network Geometry, Size of Network



VLBI

SLR



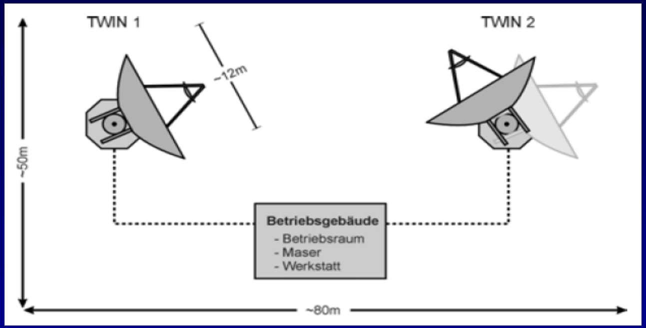
Future GGOS Core Network

Core Network (~ 40 Stations):

- **2-3 VLBI telescopes** for continuous observations
- **SLR/LLR telescope** for tracking of all major satellites
- At least **3 GNSS antennas and receivers** (controlled equipment changes)
- **DORIS beacon** of the most recent generation
- **Ultra-stable oscillator** for time and frequency keeping and transfer
- **Terrestrial survey instruments** for permanent/automated local tie monitoring; crucial for the combination of the techniques
- **Superconducting** and **absolute gravimeter** (gravity missions, geocenter)
- **Meteorological sensors** (pressure, temperature, humidity)
- **Seismometer** for combination with deformation from space geodesy and GNSS seismology
- **Additional sensors**: water vapor radiometer, tiltmeters, gyroscopes, ground water sensors, …

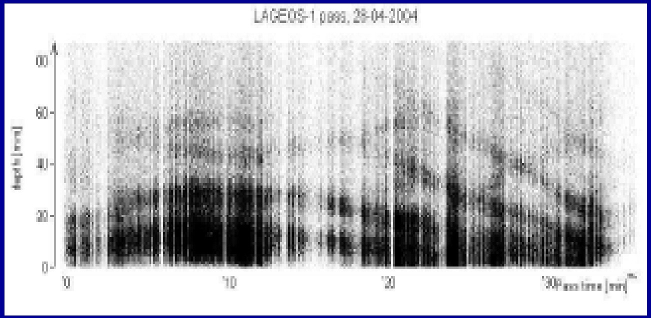
General Characteristics: highly automated, 24-hour/365 days, latest technologies

Innovation in Ground-Based Infrastructure:



VLBI Twin Telescope (Wettzell)

VLBI:
- High slew rates (> 5 deg/s)
- 1-3 small telescopes at a site
- Continuous frequency range (2-18 GHz)



kHz Laser: Lageos Spin (Graz)

SLR:
- kHz laser technology
- 2 frequency systems
- Higher quantum efficiency

DORIS Beacon (Thule)

DORIS:
- 3rd generation DORIS systems

Galileo Experimental Sensor Station (GESS)

GNSS:
- GPS, Glonass, Galileo, Compass, …
- Sampling > 10 Hz
- Real-time
- 3 antennas/receivers

Organizational Aspects

- **Intensify cooperation** between the Services IERS, IGFS, IGS, IVS, ILRS, IDS and with GGOS

- Consider **organizational improvements** on how to make progress in a certain field:
  - Distribution of work among few ?
  - Setup of expert groups ? Setup of Working Groups ?
  - Regular meetings of all Analysis Coordinators and Chairs ?
  - Discussion forum (Wiki) for exchange of information ?
  - Repeat the UAW concept ? Improve it ?

General Remarks

- Keep your presentations **short**: we need the discussion time
- Concentrate on the **problems and challenges** to be solved and not on the status quo (we are all experts !)
- Chairmen: keep the time (without preventing important discussions)
- Discussions and questions during the presentations are welcome (workshop atmosphere)
- Everybody to **work toward concrete problem solutions**, action items, time planning etc.; this should be the final goal of the discussions
- Consider **new organizational ways** to achieve progress (expert groups, WGs, meetings, workshops, …)