GPS Data Products for Solid Earth Science

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• GPS Background

• Goals of our project
  – Produce and deliver high level data products from SCIGN for non-GPS experts

• Status
  – Architecture
  – Milestones
  – Products
  – GPS Explorer
Background on GPS processing

- Expansion of global GPS networks
- Increased computer throughput
  - 1990
    10 stations x 20 days of data = 1 graduate student
  - 2004
    1000 stations x 20 days of data < 15 CPU days (2.4 GHz Intel processor)
- Evolution of GPS precision
  ~1 ppm to < 1 ppb
Background on GPS processing

- **“New” error sources**
  - Monument noise
  - Reference frame stability
  - Global scale atmospheric mass transport
  - Antenna calibrations (phase centers)
  - etc.

- **“New” signals**
  - Transient and non-linear
  - Tectonic
  - Hydrologic
  - Atmospheric

- **User shift**
  - Independent PIs/GPS experts with their private networks
  - Continuous, open networks and large observatories
  - Open raw GPS data and data products
    - GSI GeoNET solutions
    - IGS Orbits

- **Expanded user base**
SCIGN

- 250 continuous GPS receivers
- A scientific experiment
- A network experiment
- Open data policy
- Primary product
  - Raw GPS data
- Two primary analysis centers
  - Verification and validation of network performance
  - Independently operated
  - Fundamentally different modeling approaches
    - Double-differenced (GAMIT)
    - One-way phase (GIPSY)
• Advisory Council
  - External, independent advice
  - Top recommendation
  • Produce a combined solution of station positions and velocities for non-GPS experts
• Analysis Committee
  – Compare results from analysis centers
    • Never done before at this scale and scope
  – Resolve discrepancies
    • Reference frame
    • Data and Meta-data
    – Produce combined product

• Analysis Center Comparison
  – Positions <= 1 mm
  – Velocities ~0.2 mm/yr
  – Manual, annual process
SCIGN REASoN Goals

• Generate higher level products from SCIGN data for use by the SCIGN community

• Apply modern IT methodology within SCIGN to:
  – Produce and disseminate higher-level data products to a larger community of
    • Scientists
    • Government agencies (Federal, State, and Local)
    • Surveyors
    • GIS professionals

• Build on current capabilities within SCIGN for data archiving, information systems, and data analysis to disseminate the following products:
  – Geodetic position time series
  – Crustal motion models
  – Strain rate maps
  – Geologic fault models
  – Near-real-time earthquake response information
  – Geodetic reference systems for precise GIS and surveying

• Improve capabilities in
  – Archiving
  – End-user interfaces
  – Delivery mechanisms
  – Data modeling

• Open source project based on a redundant, multi-tiered “Virtual Archive” for GPS applications.
High Level Requirements

• Requirements
  • Data Products are “scientific publication” quality
    – Verified, validated, and reference-able
  • Processing centers and processes use the same input data and meta data

• Goals
  • All processing retrieves data from a common source
  • Products are quantified, reproducible, and based on verified and validated data and established processes
  • Web distribution of products contains complete information on product generation (traceability)

• Objectives
  • Employ GPS Seamless Archive
  • Interface through Web services
  • Pull data at time of analysis
  • Push results into archive
  • Pull products from archive for distribution
  • Provide full accounting of product
  • Provide tools/recipes for product reproduction
  • Provide On-demand analysis
Products

- Verified and validated combined solution
  - Time series of station positions (2005)
  - Velocity field (2006)
  - Strain maps (2007)
  - Geophysical parameters - e.g., fault parameters, aquifer undulations (2008)

- Access to input data sets
  - GPS raw data and meta-data
  - GAMIT and GIPSY time series

- Network performance metrics

- Web interface
  - Web services for product distribution
  - GPS Explorer
    - Exploring information content of data products

- Recipes and On-demand products
• Architecture
  – Framework is defined based on web services
  – Interfaces are being defined, developed, and documented on the web

• Combination
  – Validated QOCA against GLOBK
  – SIO and JPL solutions are being combined with QOCA
  – Producing web products using interim interfaces on a weekly basis

• GPS Explorer
  – Prototype web portal for exploring GPS data products
    • http://reason.scign.org
  – Combined products being posted on web on a weekly basis

• 2005 Milestones
  – Combination based on prototype web services by SCIGN annual meeting in Spring 2005
  – Combined products based on web services by July 2005
SCIGN REASoN CyberInfrastructure

- Structured around four systems
  - Product Input
    - Seamless Archive a community based system
    - Via web services
  - GPS Data Processing
    - Verified and validated products using 2 independent systems
    - GAMIT and GIPSY
  - Product Generation
    - Based on QOCA software
  - Product Delivery
    - Via Virtual Archive
    - With web services
      - Meta data
      - Products
- Extensible to EarthScope Needs for High Level Product Generation and Distribution for
  - PBO
  - SAFOD
  - USArray
High Level Architecture

Future SCIGN Cyberinfrastructure v1.0 - 02/2004
“layered component model”

SCIGN Data and Application Portal

User

Portal

Central SCIGN Servers

SCIGN Resource Engines
SCIGN Resource Catalogs
SCIGN Resource Brokers (Web Services)
SCIGN Resources (XML)

SCIGN Data & Products Generation
Scientific Research
Scientific Analysis
Data Management
Data Collection
Instrumentation

Framework

Tools

Maps
2D & 3D Models
Charts & Graphs
4D Tours
QC & Status
Source Data
Metadata
Software
Multimedia
Forums
Glossary

Complementary SCIGN Software

SCIGN Adaptive Data Center

Mapping
Timeseries
Reports
Format & Export
Charts & Graphs

SCIGN Database

GPS Data
Geodetic Monument
GPS Velocity
Strain

Supplementary Spatial Library
Multimedia Library
Seamless Archive

Data
Metadata
Products
Concepts & Rules
Models

GPS Data & Metadata
GPS Velocity
Strain
GPS/Seismic Data

Other Products
GPS/Seismic Products

Data + Metadata

November 1, 2004
SCIGN REASoN Project
Combination Status

- Producing web products using interim interfaces on a weekly basis
- Products extend back to 6 months and counting
- Available at
  - http://reason.scign.org/
- Open issues to be addressed in 2005
  - Reference frame
  - Relative weighting
  - Quality assurance strategy
  - Desired latency for products
  - Sub-network strategy
  - Regional filtering strategy
GPS Explorer

- The web portal for accessing SCIGN products
- Documents project including
  - Overall project description
  - Interface definitions
- Provides access to SCIGN Products
  - Combined solution
    - Combined solution based on
      - SIO and JPL solutions
      - Combined using QOCA
    - Graphical representation of combined time series and network performance metrics
      - Overlay data
- Updated weekly
- User Forum
Welcome to the SCIGN Data Portal, developed as part of a NASA REASON cooperative agreement. The Portal is designed to provide high-level GPS data products to the GPS community and beyond, using advanced information technologies. These products include position time series, crustal motion models, and strain rate maps.

More information on the portal and this REASON project is available.

What's New
- SCIGN Data Portal in development: give us your feedback
- JPL Status Report, 2004 SCIGN Annual Meeting: REASON overview
- Testing production of SCIGN combined time series using Q0CA combination software
- Development of web services to provide SCIGN metadata from SOPAC database directly to users, via command-line programs
- XML schema creation for uniform metadata input to GAMIT and GIPSY

REASON Project Goals/Products
- Produce and disseminate high-level SCIGN data products (e.g., combined time series, strain/fault slip rates) using new technologies, such as web services
- GPS Explorer, an online, integrated database/data discovery and research tool. This is envisioned as the primary tool for access and visualization of SCIGN data products.
- Adaptive Seamless Archive System using web services for GPS data discovery, exchange and storage to enable the next generation of the Global Seamless Archive Center (GSAC)
- An open-source project, the “Virtual Archive”, which uses web services and other new technologies for improved data archive administration and access
- Provide contextual spatial services (GIS) layers to the GPS community

Participating Agencies
(note: this project supports SEEDS efforts)

SCIGN REASON Project
Summary

• Developing a system for producing and delivering high level GPS data products for SCIGN
  - Based on verifiable and validated processes
  - Reliable, reproducible, and documented
  - Use a process that is extensible to larger networks

• Products to be delivered using
  - Modern information technology
  - Web services and interfaces
  - And an interactive web portal for exploring information content of products

• Interim system is running at http://reason.scign.org/
End