

GAMIT/GLOBK In A Day*

M. Floyd and T. Herring

Massachusetts Institute of Technology

GAGE/SAGE Science Workshop

Pre-Workshop Course

9–10 August 2021

http://geoweb.mit.edu/gg/courses/202108_GAGE-SAGE/

Material from R. W. King, T. A. Herring, M. A. Floyd (MIT) and S. C. McClusky (now at ANU)

*Or two half-days in the world of virtual workshops

What is GAMIT/GLOBK?

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- GAMIT/GLOBK is a suite of software to reduce GNSS phase and pseudorange (raw) data to geophysical quantities such as positions, velocities and other geodetic parameters
 - GAMIT is the collection of programs that processes the phase and pseudorange data to generate a network solution vector and associated loosely constrained covariance matrix
 - GLOBK is the collection of programs that manipulates and combines phase-and-pseudorange solutions, not just from GAMIT processing, to calculate final positions, velocities and other geophysical parameters
 - The two packages of programs are distributed together as “GAMIT/GLOBK”
- GAMIT/GLOBK is command-line software that is written mostly in Fortran, with some C, and a lot of shell scripts with which users interact to operate the main programs
 - It is *not* graphical user interface (GUI) software within windows, with clicks and drag-and-drop functionality

Structure

- Scripts that control GAMIT and GLOBK, and most programs, have a built-in help page which can be viewed by entering the command name only
 - `~/gg/com/` contains all of the scripts used
 - `~/gg/gamit/bin/` and `~/gg/kf/bin/` contain the program executables
(`gg` is a link in your home directory that points to the directory with the GAMIT/GLOBK software installed and should not be removed)
- Once the software is installed, user selects data to be processed over some interval of time and uses `sh_gamit` for batch processing
- GLOBK is used after the daily processing to combine results and set the reference frame

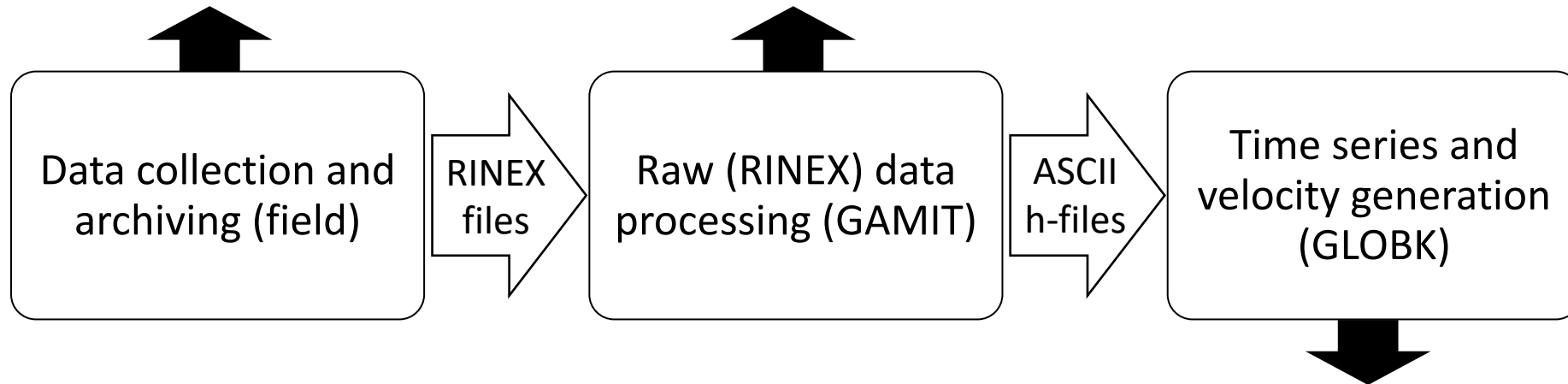
Basic stages of GAMIT/GLOBK for geoscience

Third-party programs

- `runpkr00`
- `teqc`
- etc.



- `model` (model observations)
- `autcln` (cleans data)
- `solve` (solve for parameters)

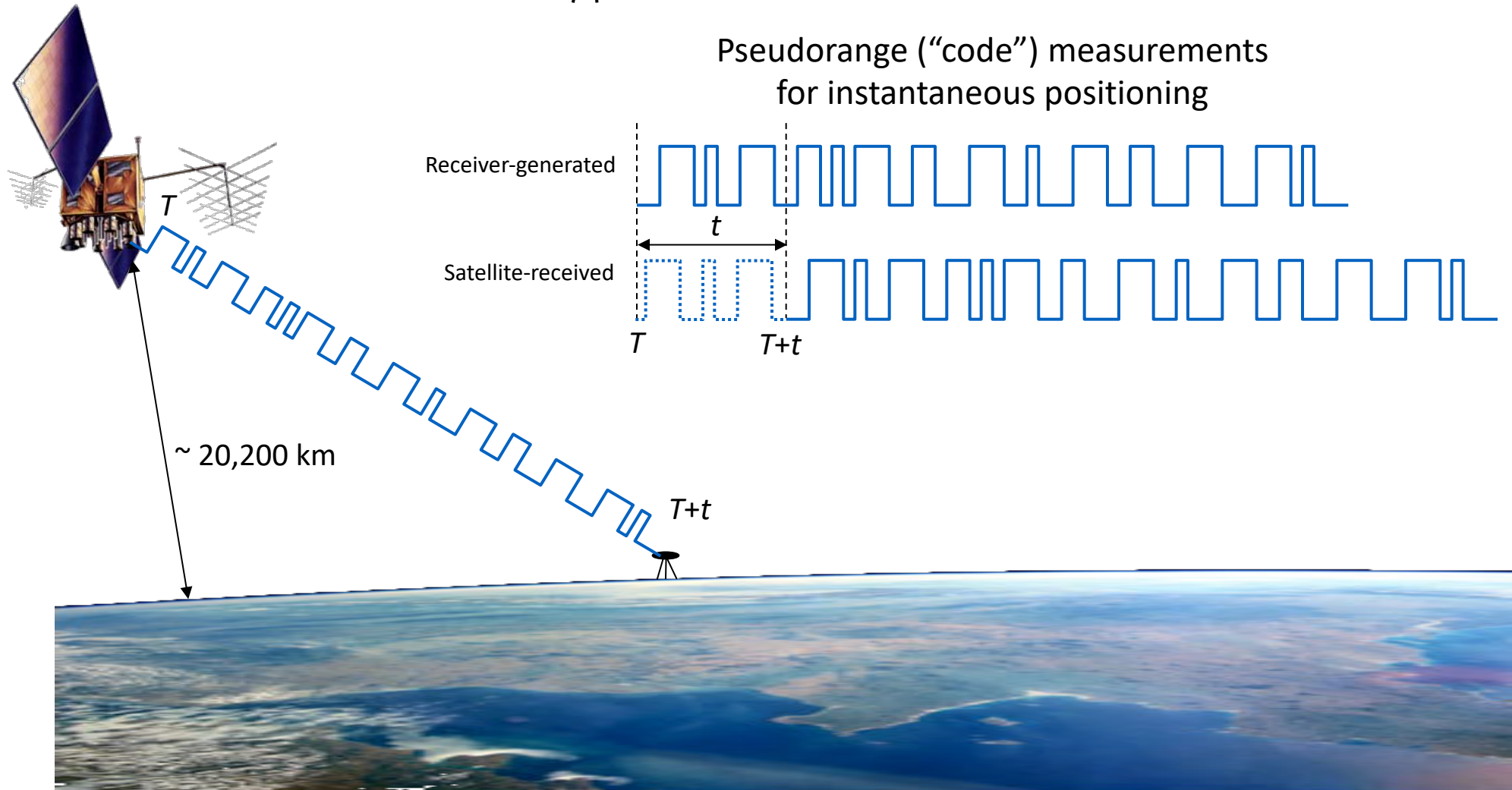


- `glred` (time series)
- `globk` (velocities)

Basic inputs and outputs

- RINEX data must be prepared or downloaded for input to GAMIT
- Output from GAMIT are plain text (ASCII) “h”-files
 - Loosely constrained network solutions with a priori parameter information, parameters adjustments and full covariance matrices
- Input to GLOBK is binary version of h-files (or equivalent formats)
 - Convert from ASCII to binary h-files using `htog1b` (or “`-opt H`” option in `sh_glred`)
- Final output of GLOBK is “.org”-file, which contains all information for
 - Time series (“.pos”-files)
and/or
 - Velocities (“.vel”-files)

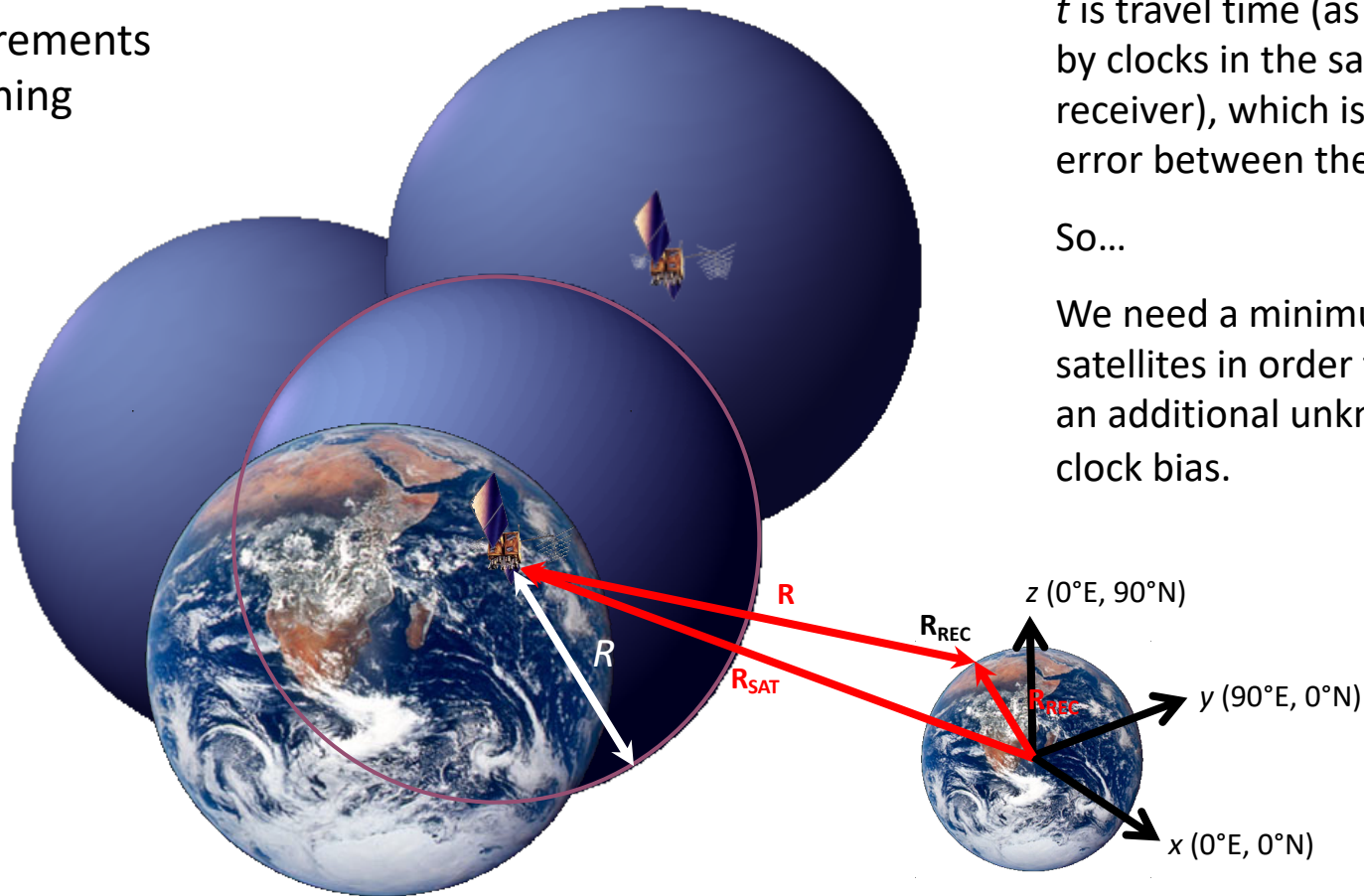
How does GAMIT^(not) work?



How does GAMIT/work?

(not)

Pseudorange (“code”) measurements
for instantaneous positioning



But...

t is travel time (as measured by clocks in the satellite and receiver), which is subject to error between these clocks.

So...

We need a minimum of *four* satellites in order to solve for an additional unknown, the clock bias.

$$R = | \mathbf{R}_{\text{sat}} - \mathbf{R}_{\text{rec}} |$$

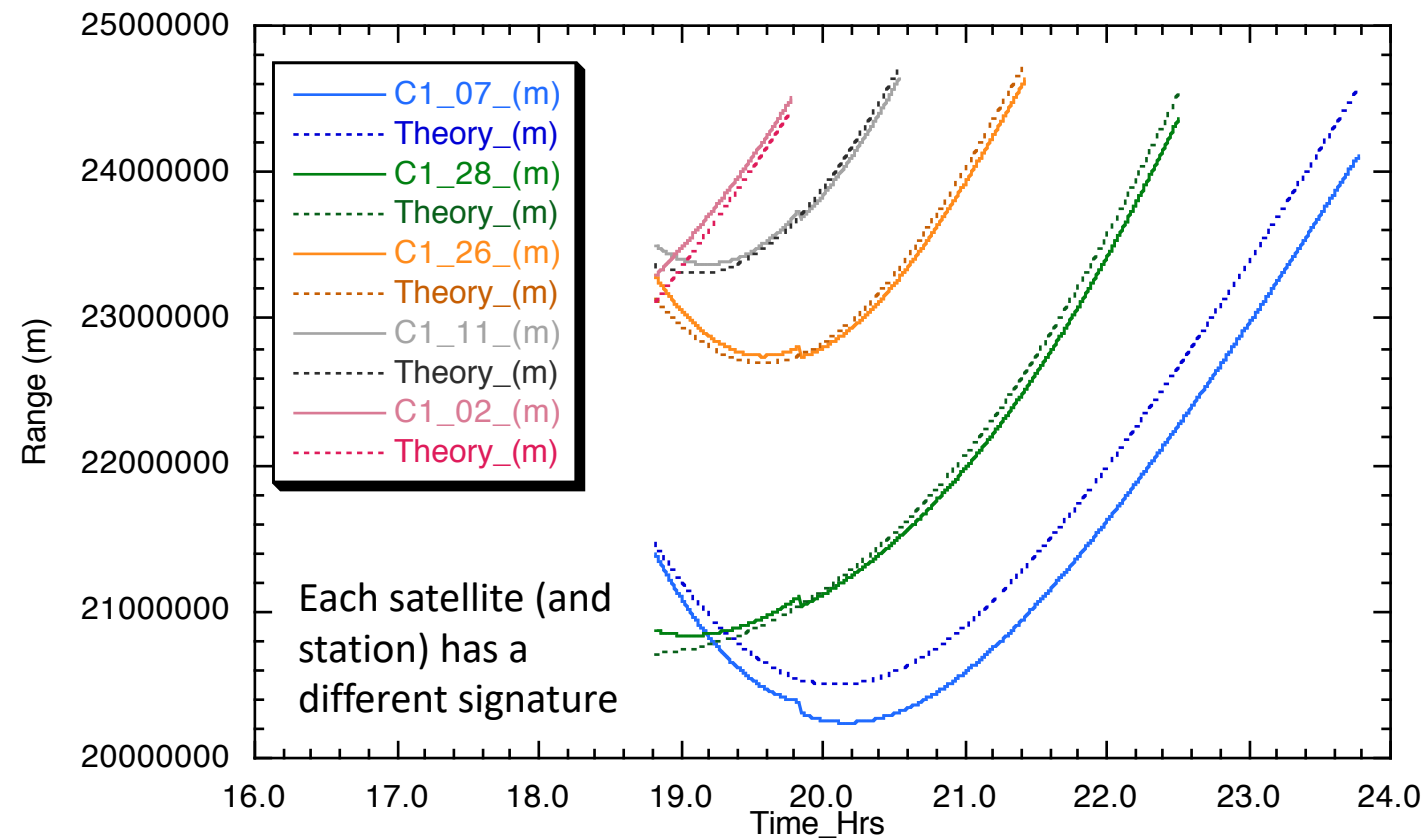
$$R = c[(T+t) - T] = ct$$

$$(ct_{\text{sat-rec}})^2 = (x_{\text{sat}_i} - x_{\text{rec}})^2 + (y_{\text{sat}_i} - y_{\text{rec}})^2 + (z_{\text{sat}_i} - z_{\text{rec}})^2$$

How does GAMIT (actually) work?

Precise positioning uses tracked *carrier phase* measurements

- High-precision positioning uses the phase observations, not pseudorange (“code”)
 - Theoretical phase is modeled to build an “observed-minus-calculated” system of equations to solve ultimately for a single position per session (normally 24-hour days)
- Long-session static tracking of change in phase over time carries most of the information
- The shorter the span the more important ambiguity resolution is



What do we need to know to process data?

- Positions of the broadcasting satellites over time
 - Provided by various analysis centers and combined by the International GNSS Service (IGS)
- Relationship between the satellite orbits above and Earth's orientation below (i.e. exactly where the pole of rotation is and how fast the Earth is spinning)
 - Provided by the International Earth Rotation Service (IERS) and the US Naval Observatory (USNO)
- Transient perturbations of the Earth's surface
 - Provided by loading estimates from ocean tides, atmosphere
- Characteristics of the broadcast signal delay through the atmosphere
 - Provided by “mapping functions”, e.g. Vienna Mapping Function tables
- Receiver and antenna used, and signal-tracking behavior of the equipment
 - Former provided by the user; latter provided by various calibration centers and combined by the IGS or National Geodetic Survey (NGS)
- Approximate positions of the sites
 - Provided by previous knowledge (e.g. in GAMIT/GLOBK's tables) or the user

GNSS available in GAMIT/GLOBK

- As of GAMIT/GLOBK release 10.70 (2018-06-13), all Global Navigation Satellite Systems (GNSSs) may be processed:
 - GPS (USA), BeiDou (China), Galileo (Europe), IRNSS (India), GLONASS (Russia), QZSS (Japan)
- GNSS data must be processed *separately* for each system in GAMIT, i.e. one cannot process GPS data and Galileo data simultaneously

How does GLOBK work?

- Reads network solution vector and associated covariance matrix information from phase-and-pseudorange processing
- Combines many such solutions from the same day and/or over time into one using a Kalman filter
- Produces time series and/or velocities as well as accompanying parameters such as offsets at discontinuities (e.g. due to equipment changes or geophysical events like earthquakes)

What do we need to know to produce a solution?

- Phase-and-pseudorange solutions we want to use
 - Provided and defined by the user
- Reference frame we want to use for the results
 - Provided and defined by the user or standard terrestrial reference frame definitions

GNSS in GLOBK

- GLOBK should work in the normal manner with either “BASELINE” (fixed orbits) or “RELAX.” (estimated orbits) mode
 - Processing in “RELAX.” mode allows the orbits to be fixed later in GLOBK, which will generate a solution equivalent to “BASELINE” mode processing
- Satellite naming scheme has changed to accommodate GNSS (htog1b lists)
 - The default in GLOBK processing is currently to retain the GPS names as PRN_xx (see globk.hlp and USE_PRNN command)
- See GLOBK lectures, including those on creating time series using `glred` and combination or velocity solutions using `globk`

Summary

- GAMIT and GLOBK are partner programs designed around one another's formats
- GAMIT processes the raw phase and pseudorange data broadcast by GNSS satellites and recorded by station receivers
 - Precise geodetic-grade solutions are achieved by phase tracking, not instantaneous pseudorange positioning like a satnav or smartphone
- GLOBK combines, and, for some parameters, corrects the results of the GAMIT processing to produce geophysically meaningful quantities like position time series, velocities and displacements at discontinuities such as earthquakes
- Multi-GNSS solutions are processed separately in GAMIT and combined in GLOBK