Update on Frame Definitions

Binational Geospatial Software Developers Summit

Phillip McFarland
Phillip.Mcfarland at NOAA.gov

Update on Frame Definitions

- Global consistency through ties to the ITRF
  - What is the ITRF?
  - How are the NSRS/CSRS aligned to the ITRF?
  - How will we try for consistency between the NSRS and CSRS using the ITRF?
- Euler pole parameters
  - Getting from the ITRF to a plate-fixed frame
  - N. American Euler pole studies

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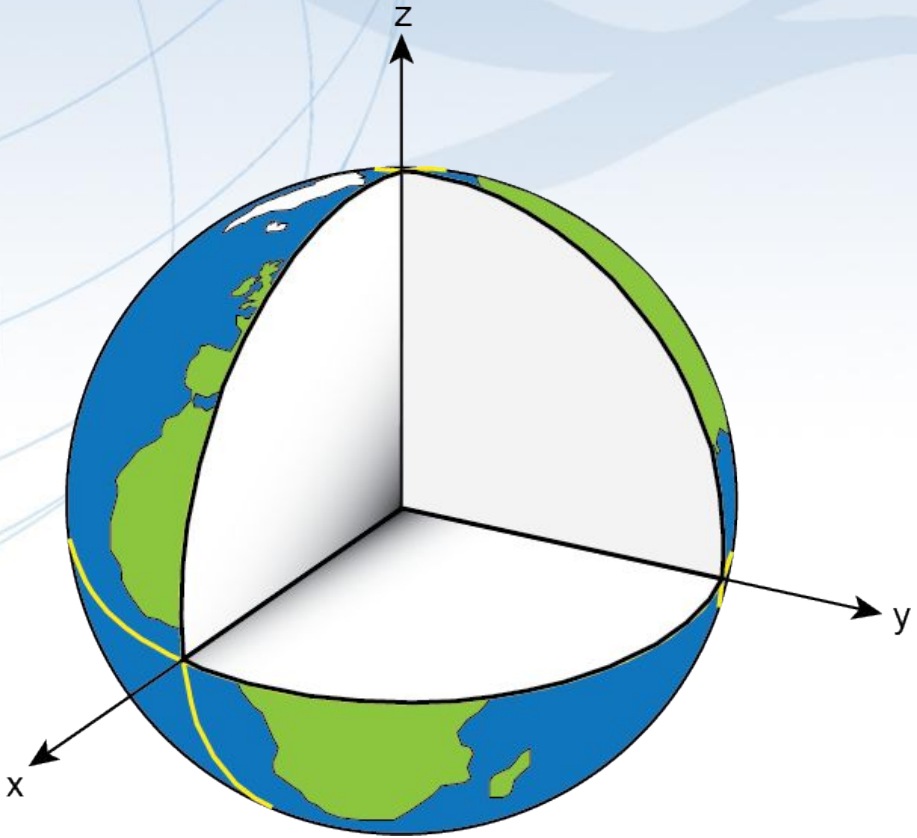
What is the ITRF?

Defined and maintained by the International Earth Rotation and Reference System Service (IERS)

https://www.iers.org/IERS/EN/Home/home_node.html

What is the ITRF?



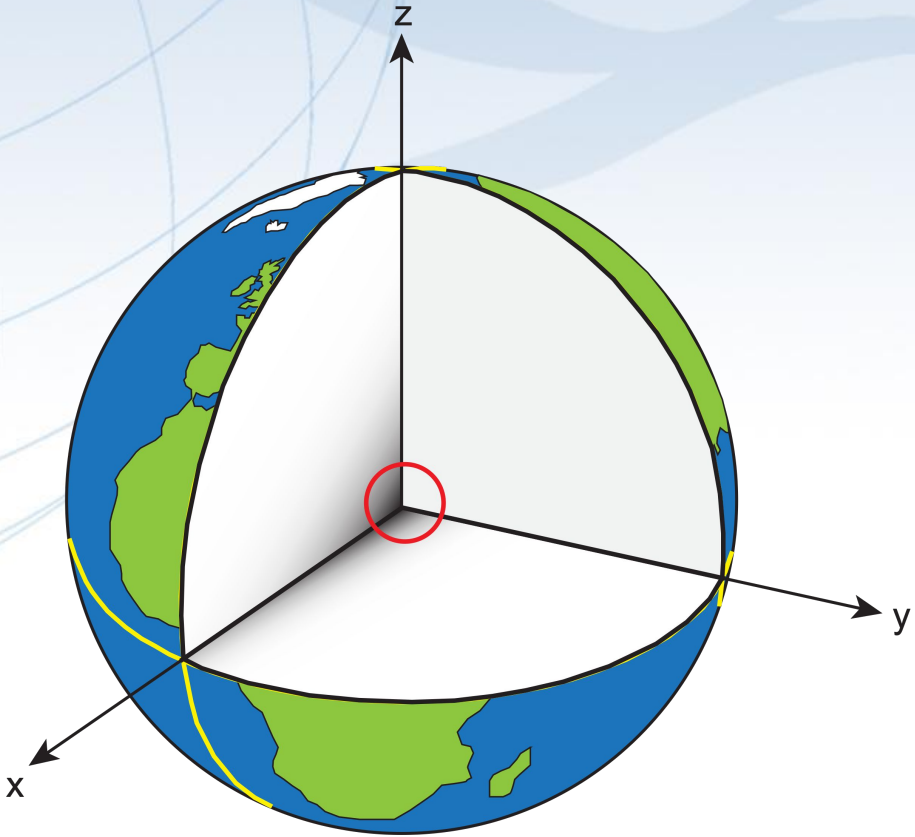
Need to define conventions for:

origin – where is the zero point?

scale – what is our measure of length?

orientation – how are the axes oriented in space?

What is the ITRF?



Origin:

Earth's geocenter; average center of total mass of Earth, including ocean's and atmosphere

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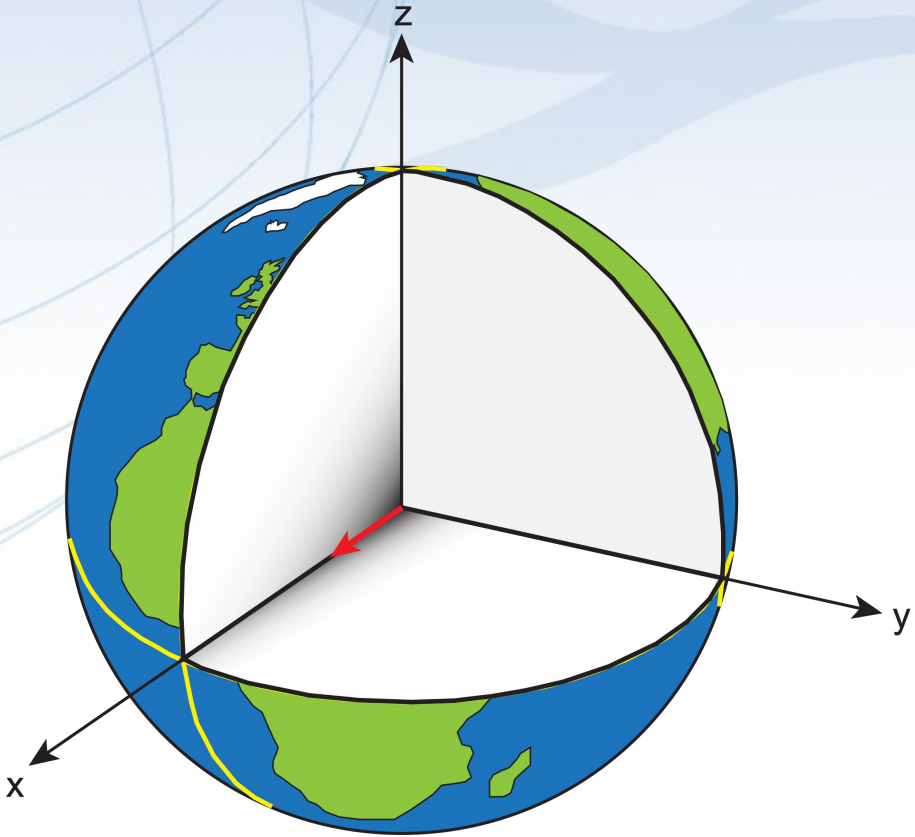
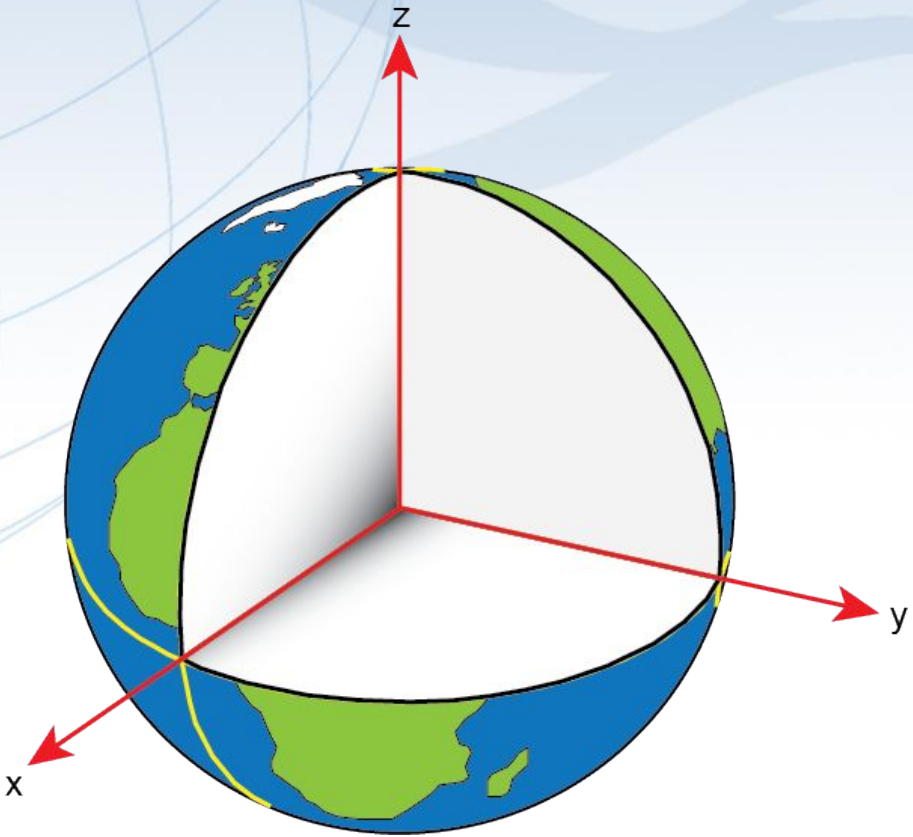


Scale:

SI unit of length, meter

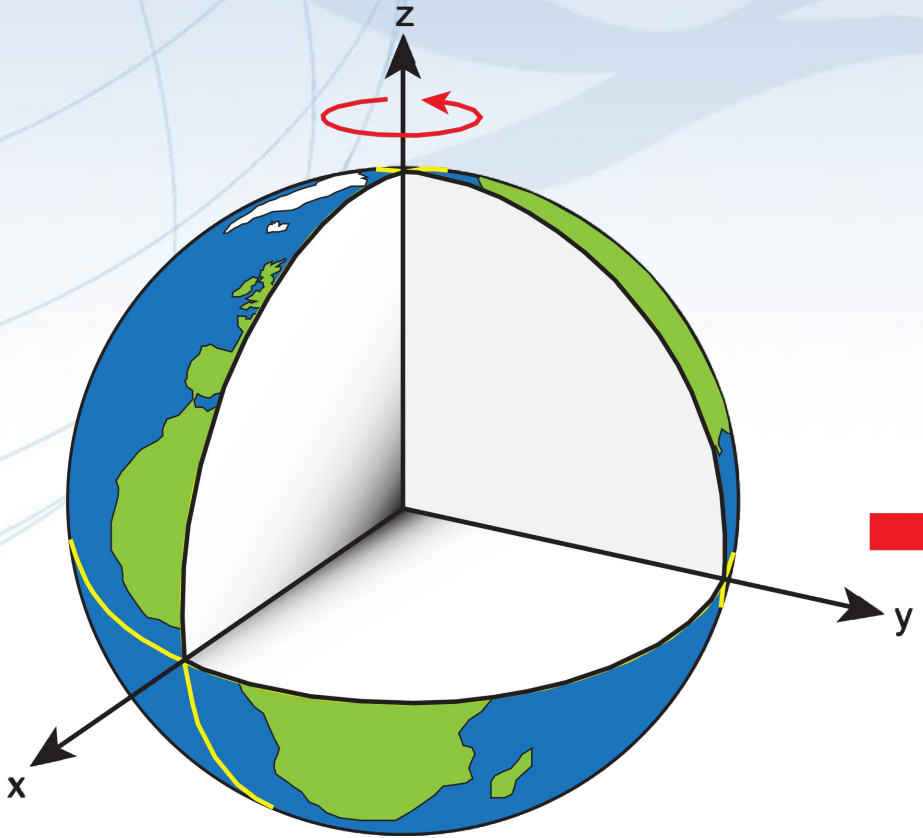
What is the ITRF?



Orientation:

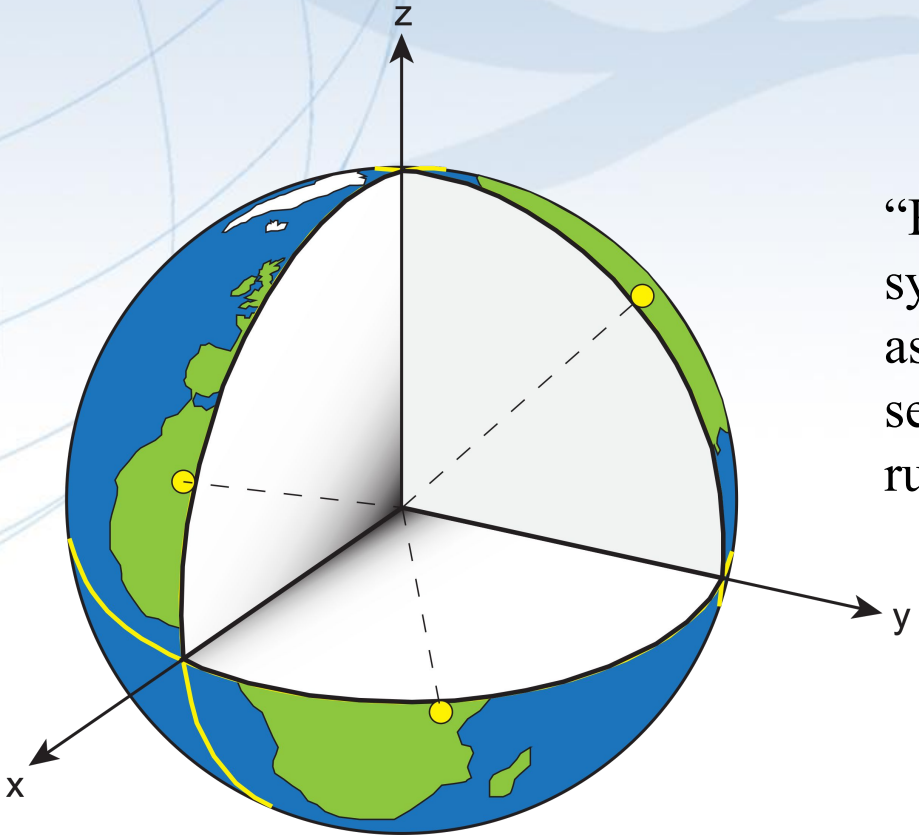
- x-axis passes through reference meridian of the *Conventional Terrestrial System* at the equator
- z-axis aligned with the *International Reference Pole*
- y-axis defined to form a right-handed system

What is the ITRF?



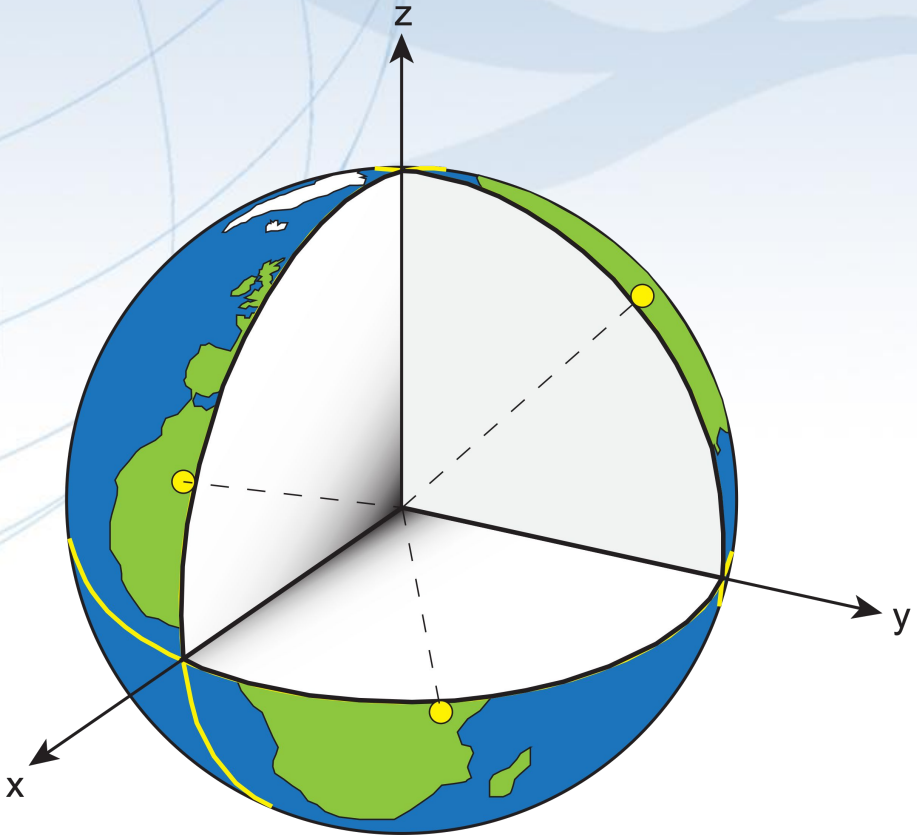
The frame rotates with and is fixed to the Earth as it orbits the Sun. It is an Earth-centered-Earth-fixed frame (ECEF).

What is the ITRF?



"Realization" of the idealized reference system occurs when coordinates are assigned to physical points in a self-consistent manner that honors the rules of the reference system.

What is the ITRF?



ITRF2020

- Released April 15, 2022 by the IERS
- Based on data from 1996 through 2020
- Solution based on data from VLBI, DORIS, GNSS, and SLR

IGS20

- Released November 27, 2022 by the IGS
- Aligned in origin, scale, and orientation with ITRF2020
- Solution based solely on GNSS data

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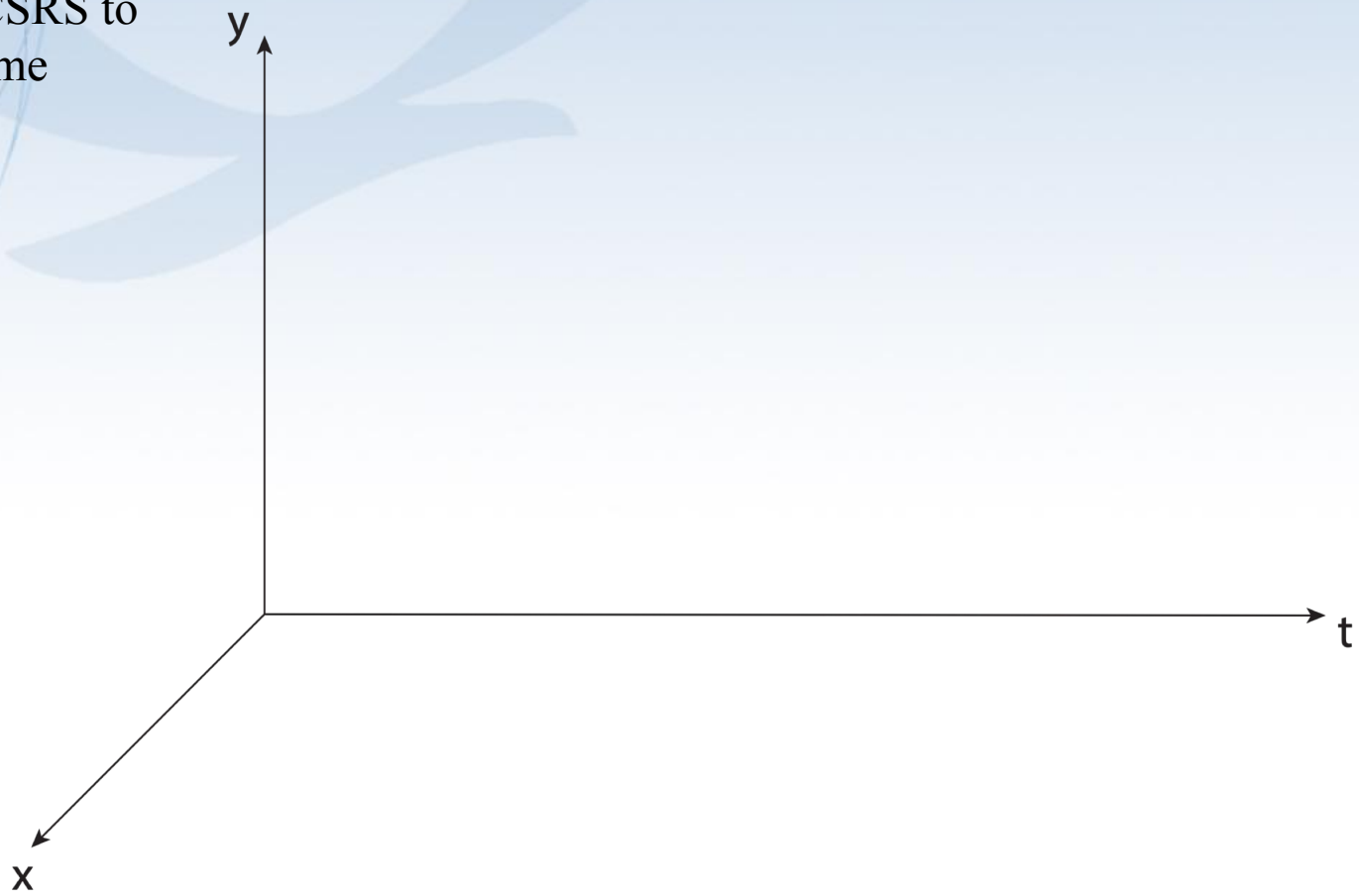
Aligning the NSRS/CSRS to the IGS reference frame



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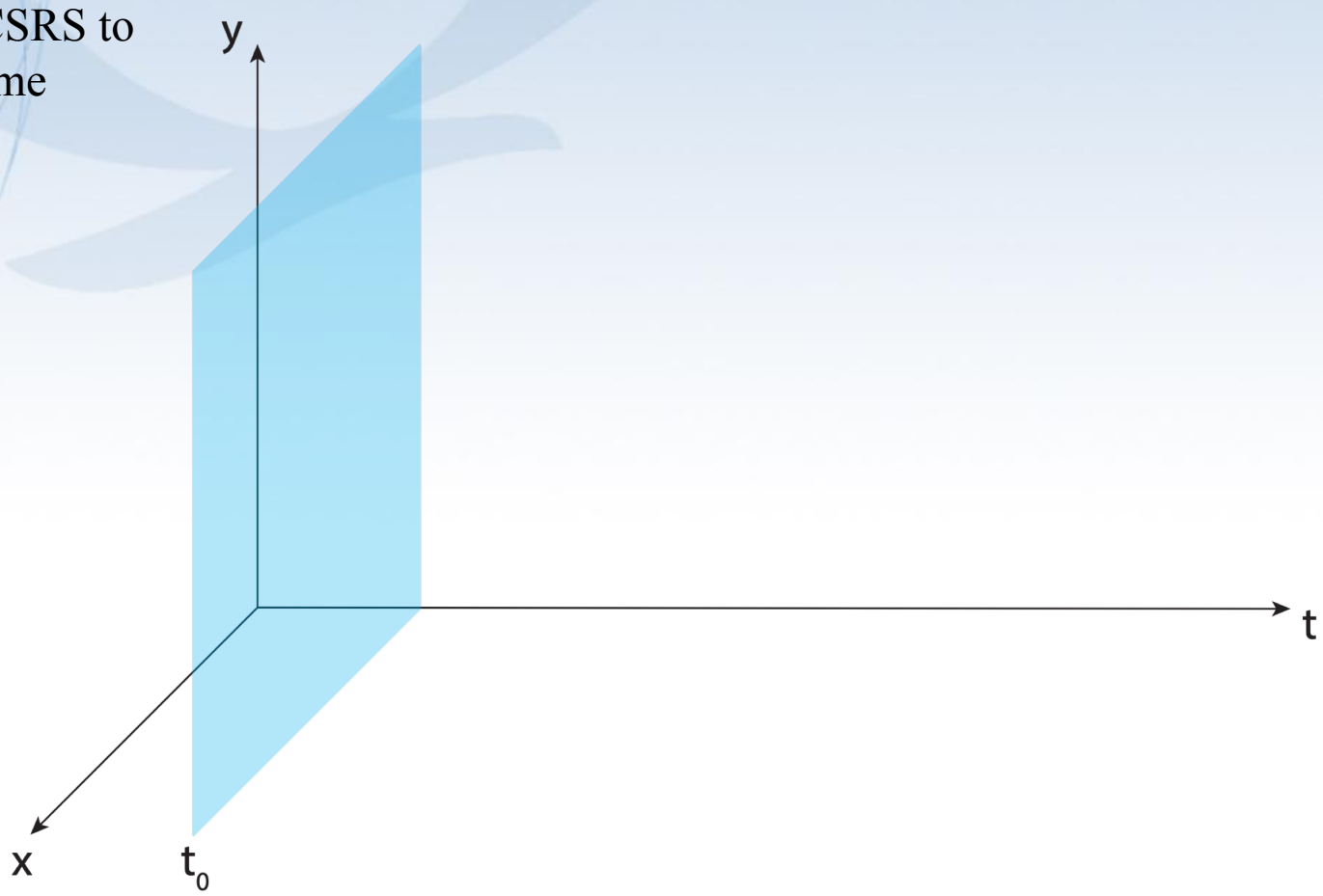
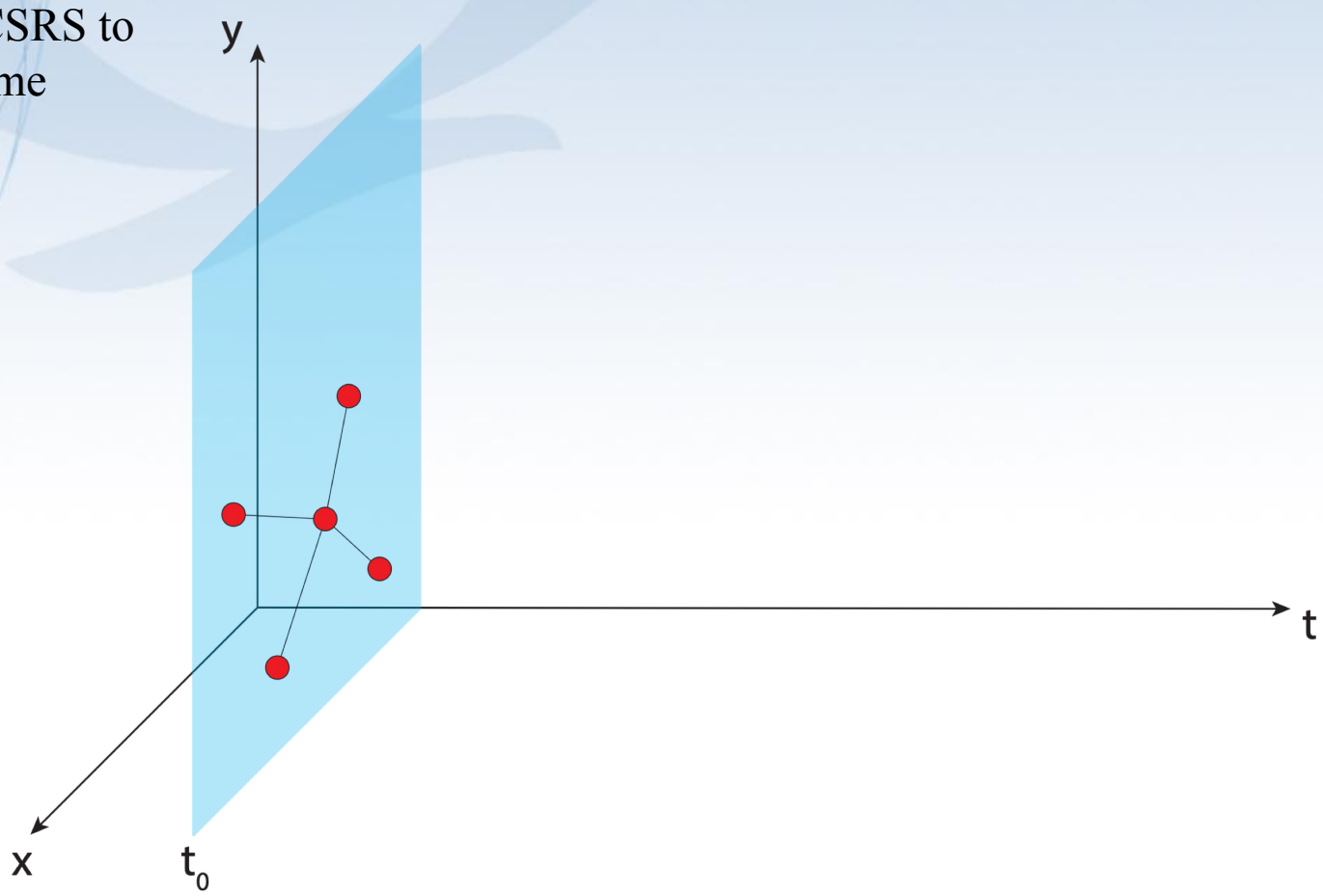


Aligning the NSRS/CSRS to the IGS reference frame

IGS GNSS station

station trajectory



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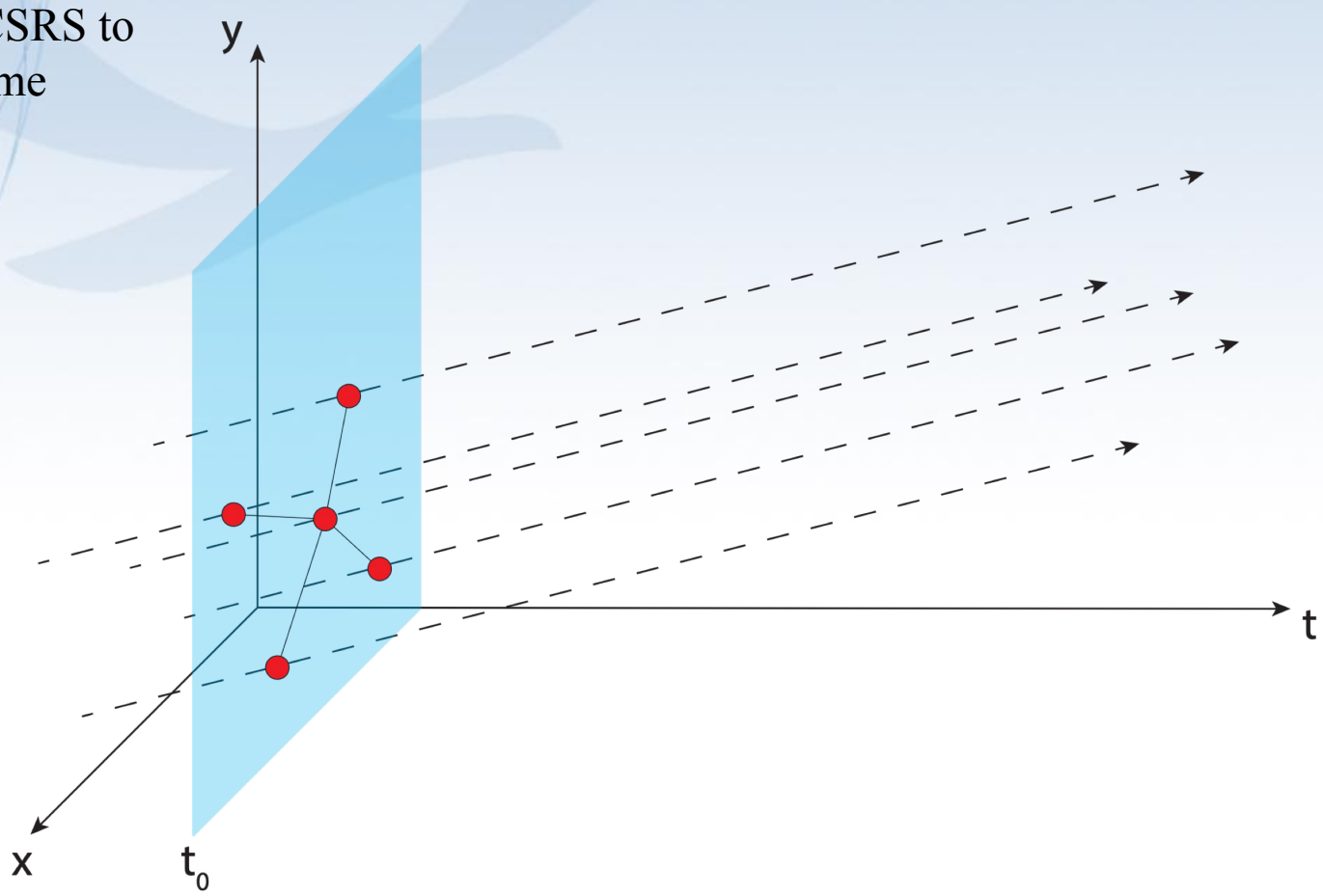
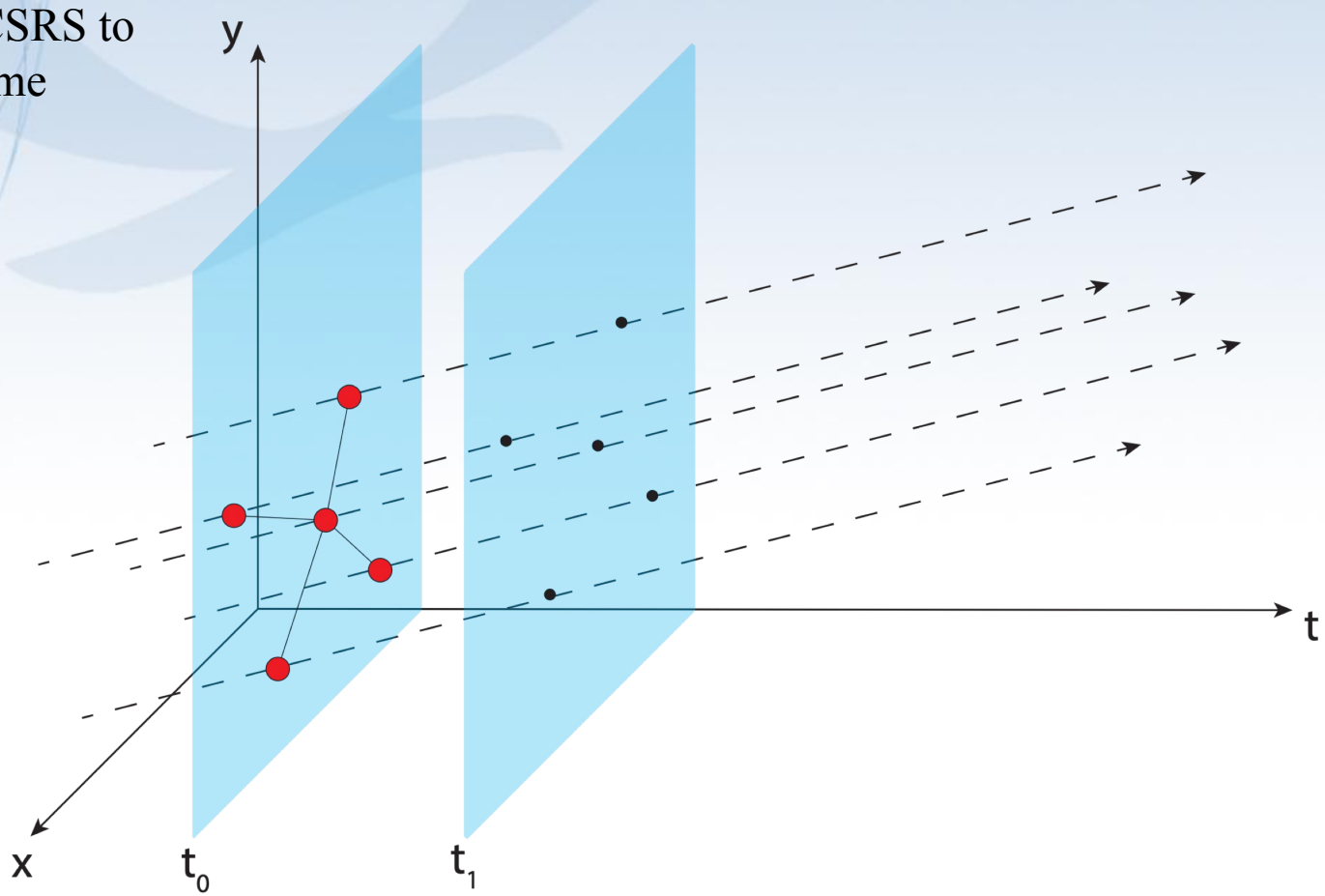


Aligning the NSRS/CSRS to the IGS reference frame

- IGS GNSS station
- station trajectory
- projected IGS station position



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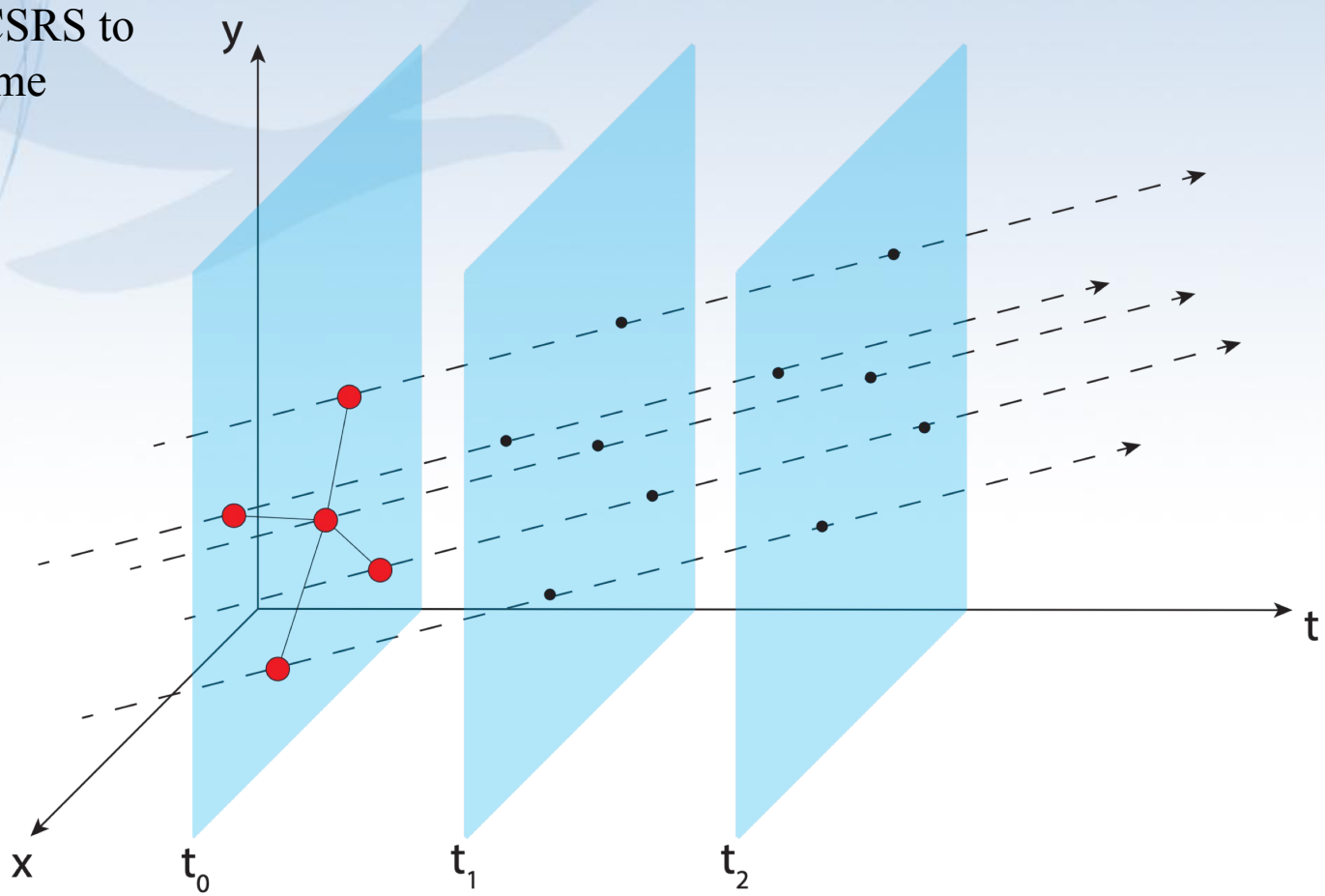

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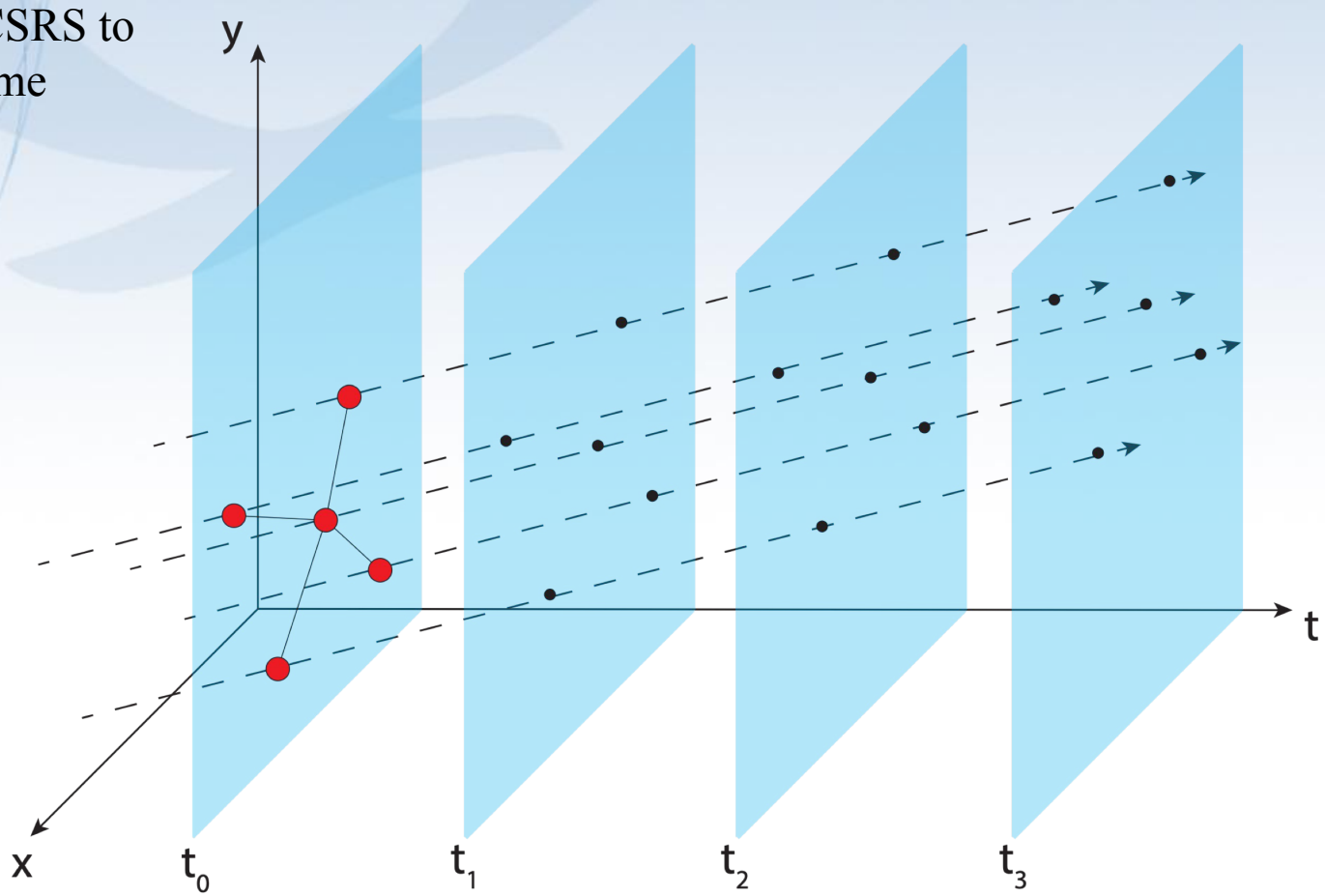

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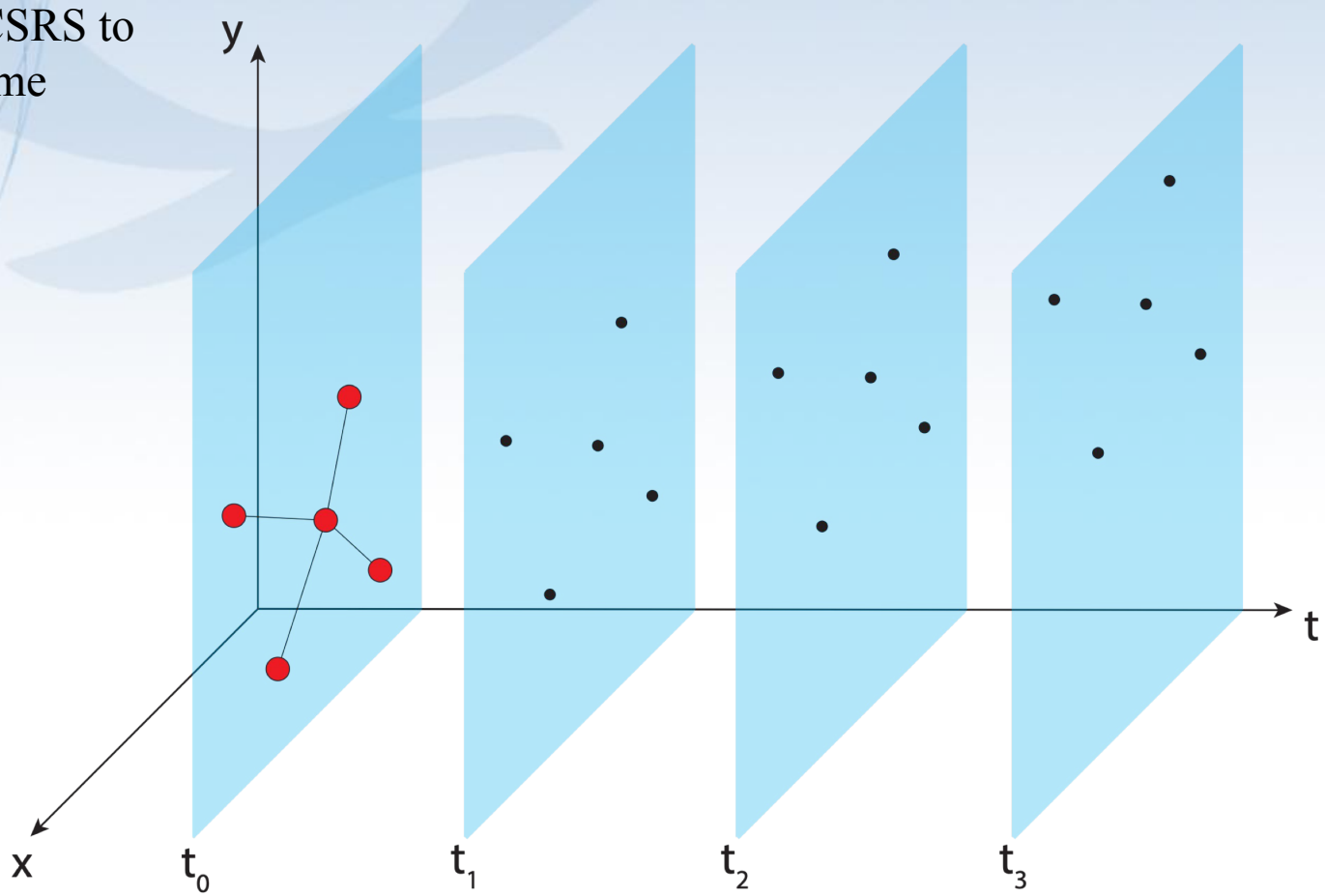

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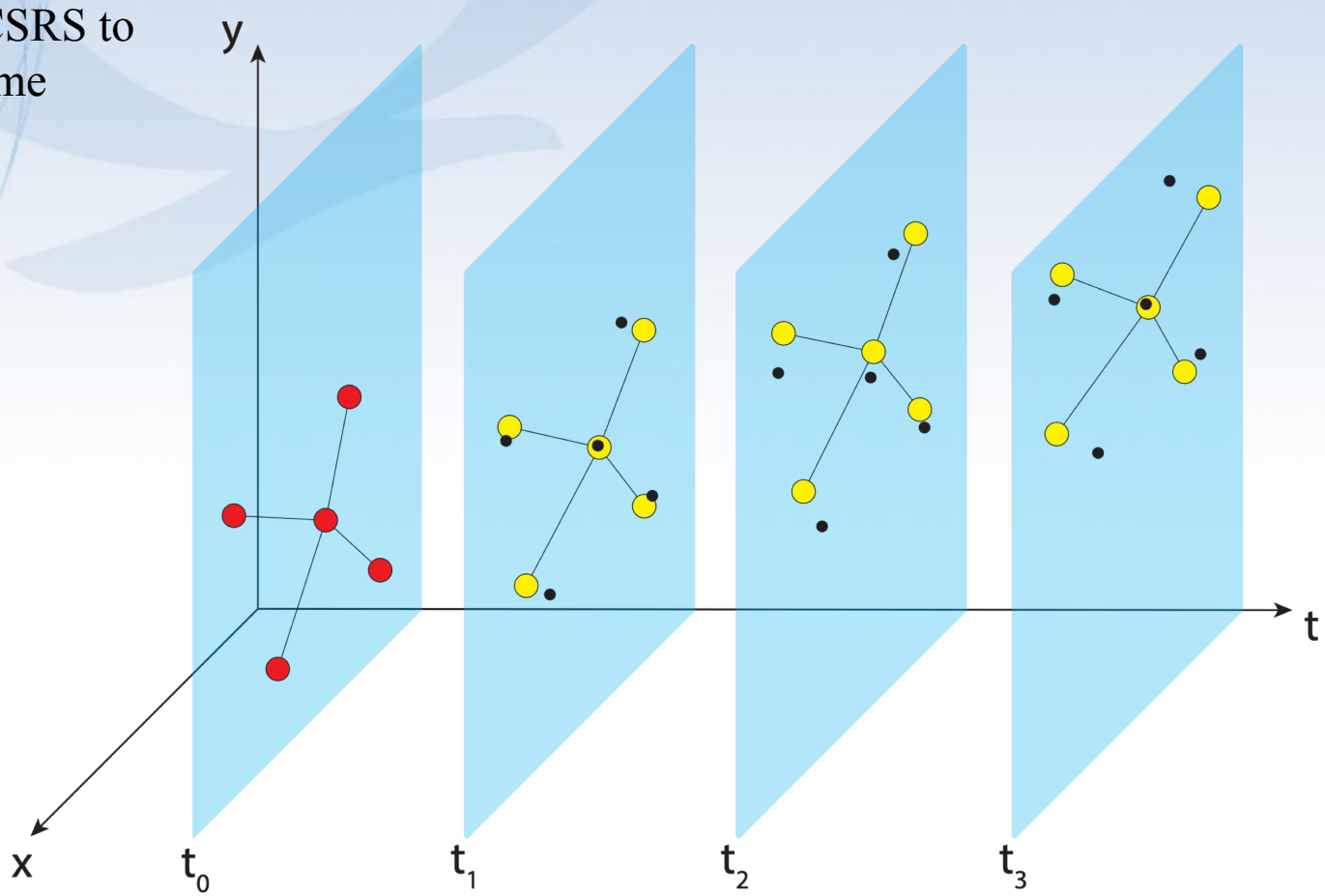

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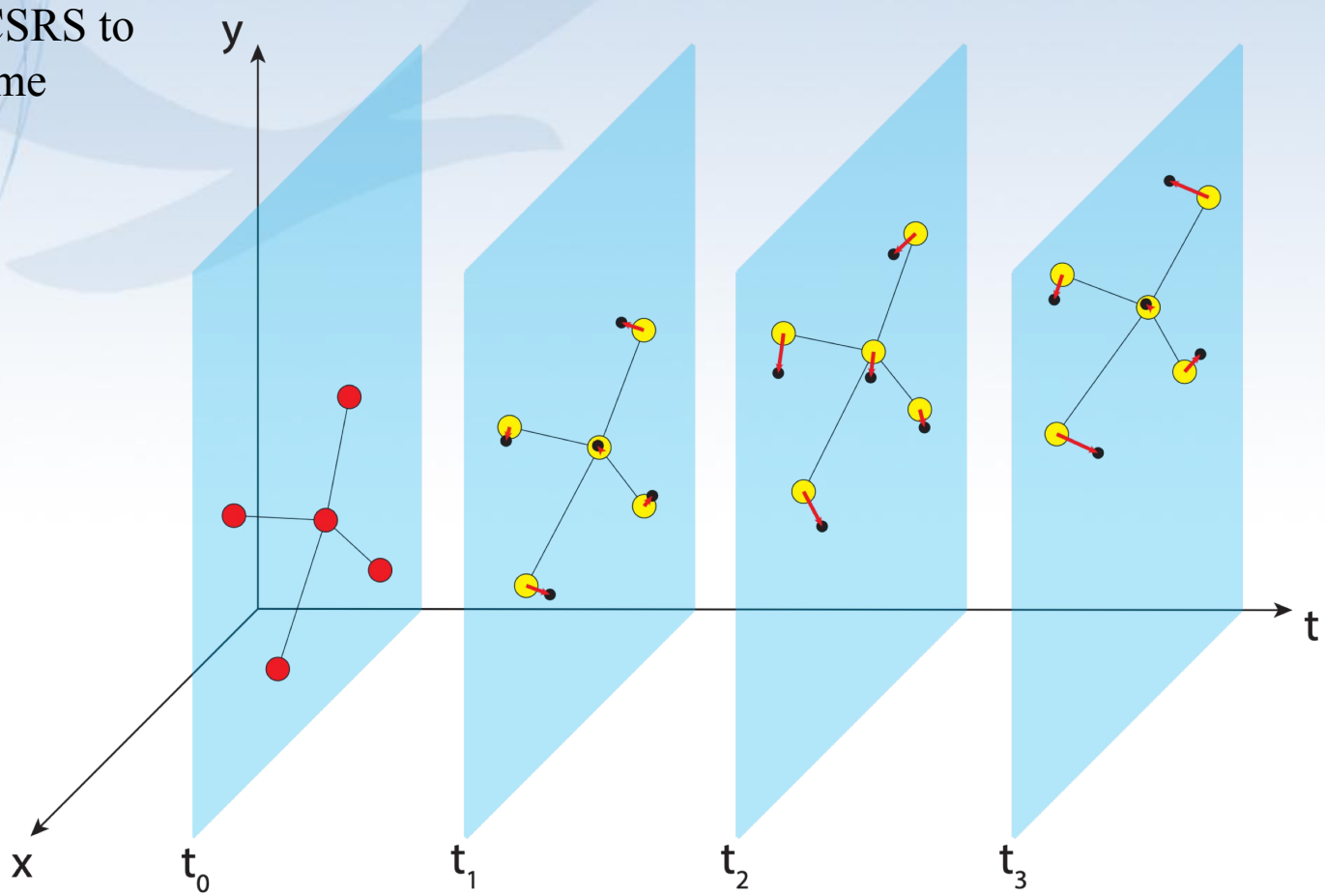

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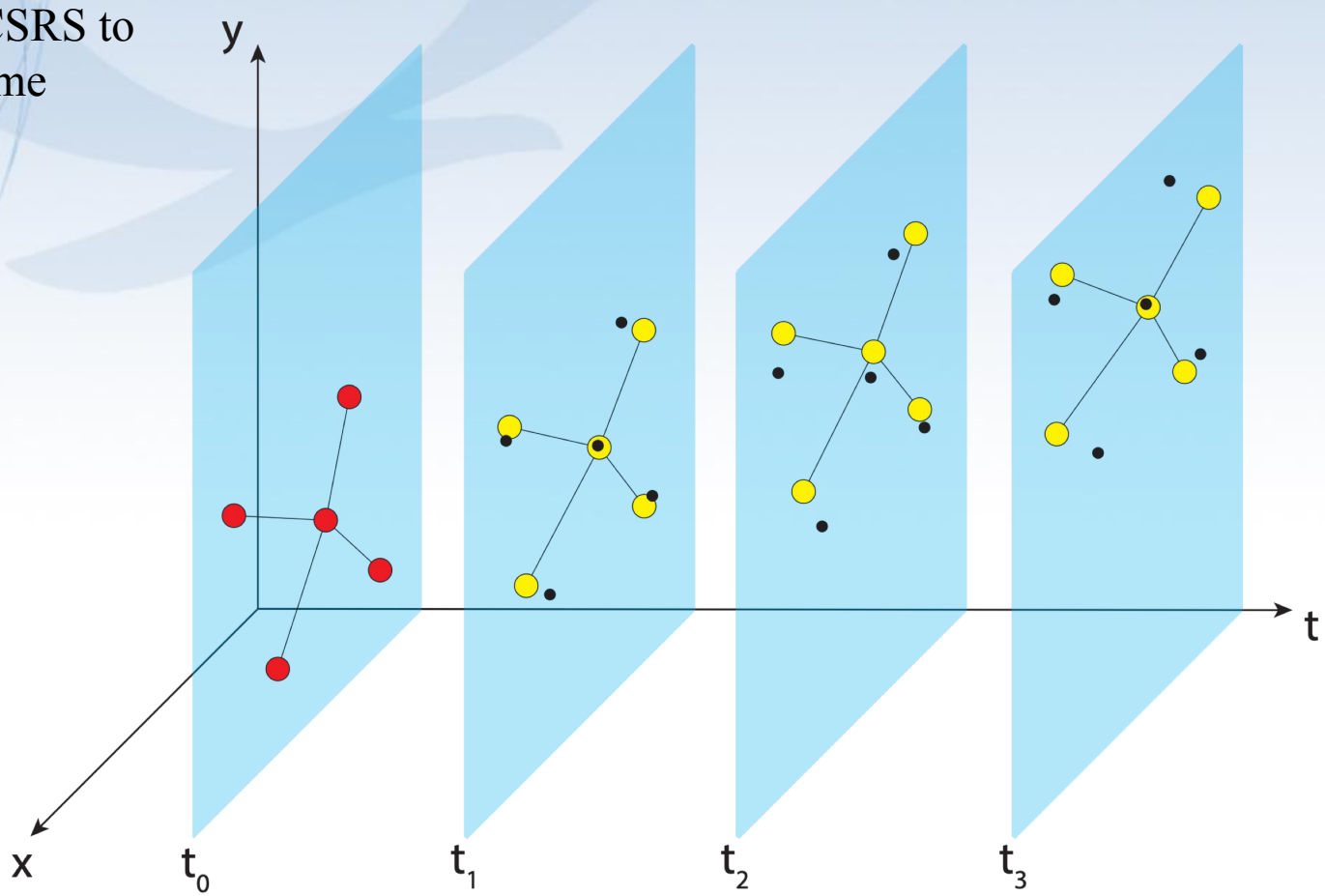

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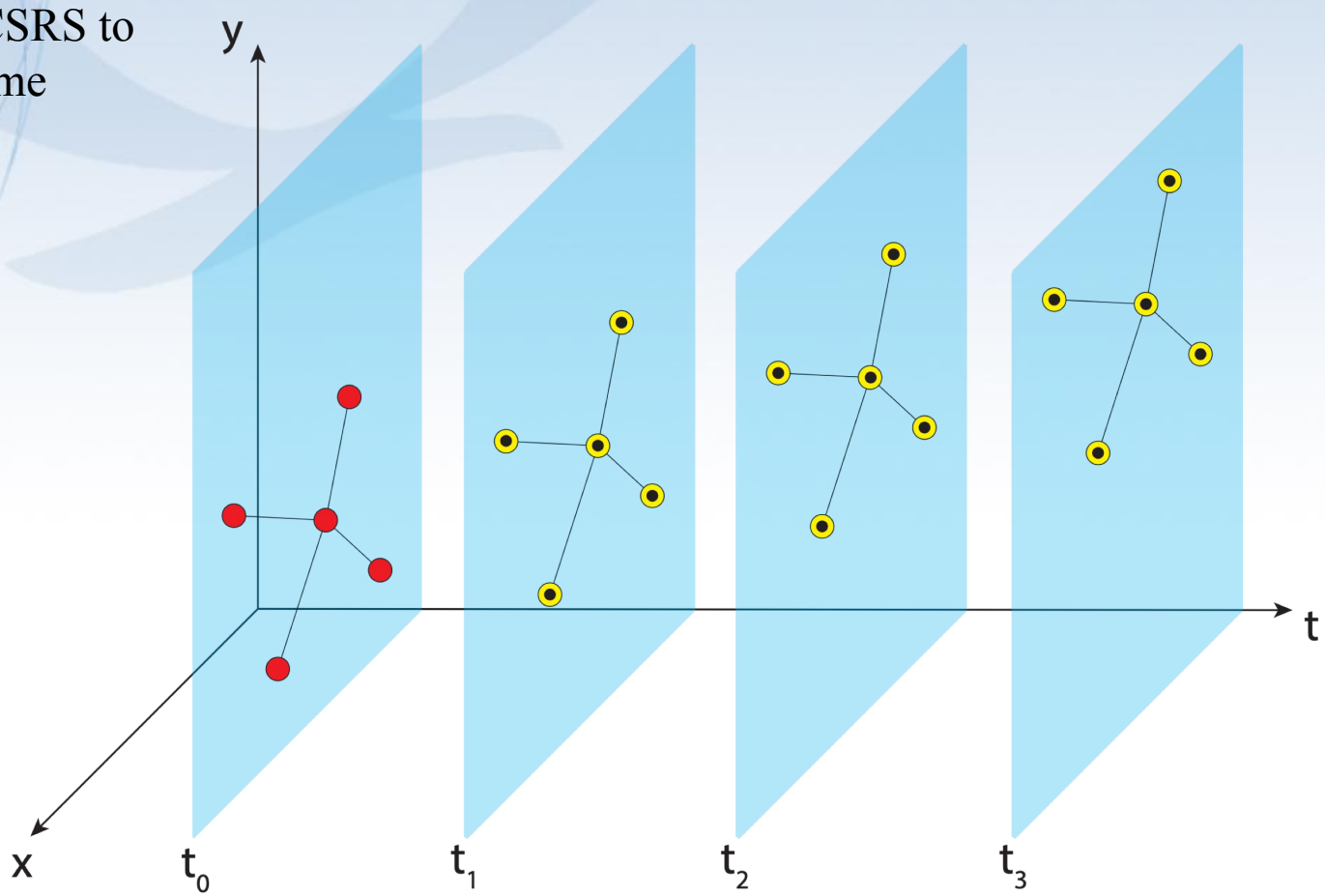

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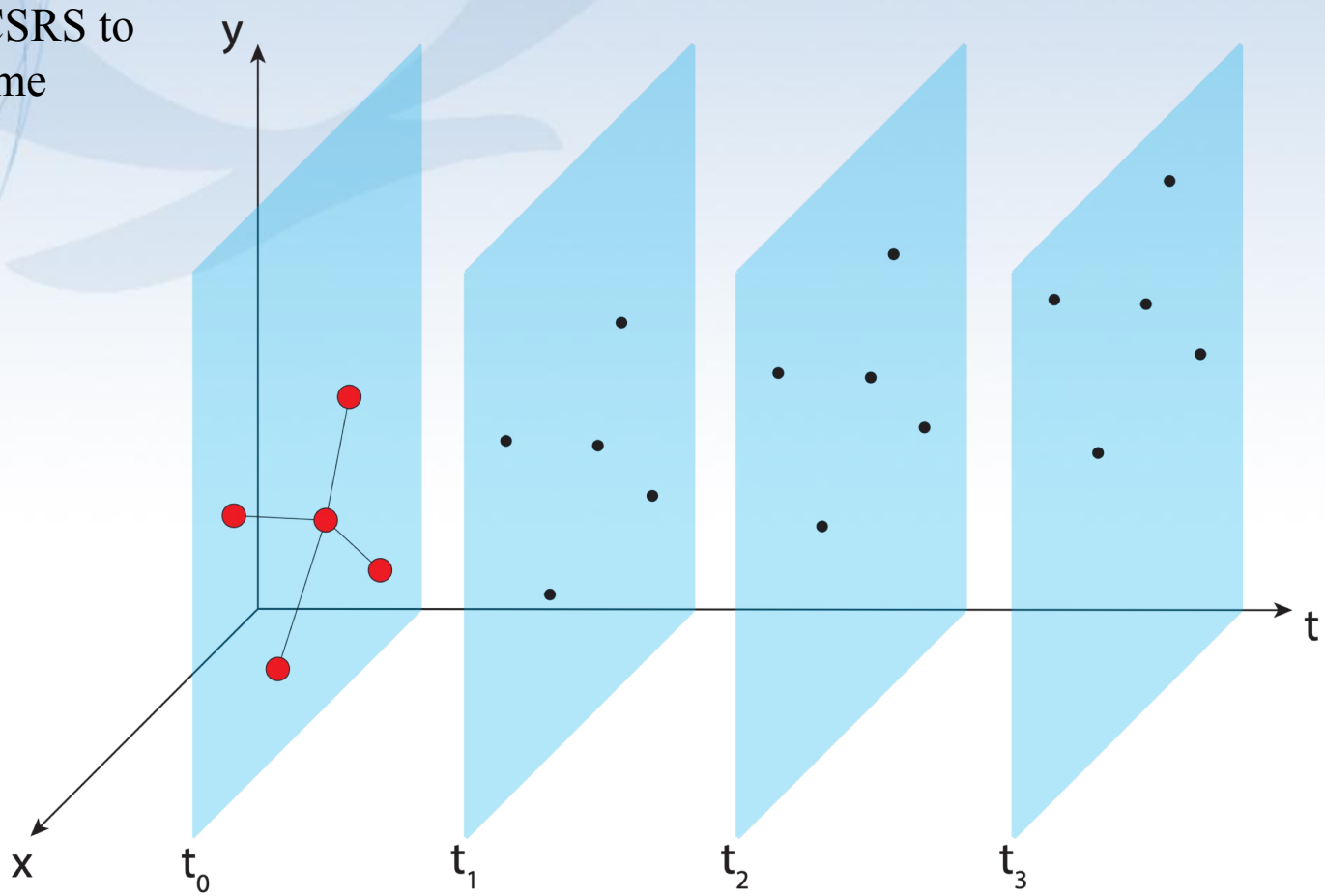

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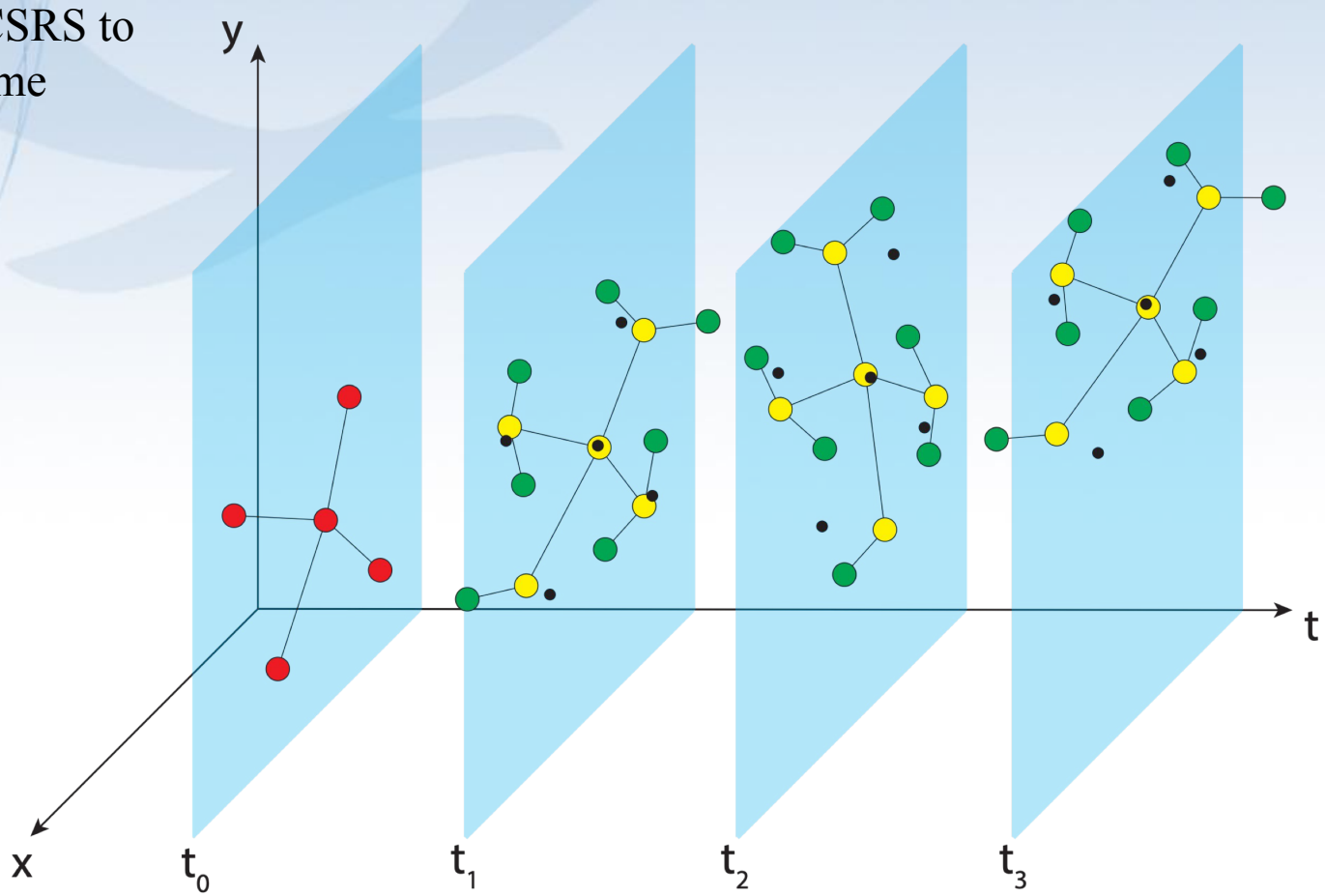

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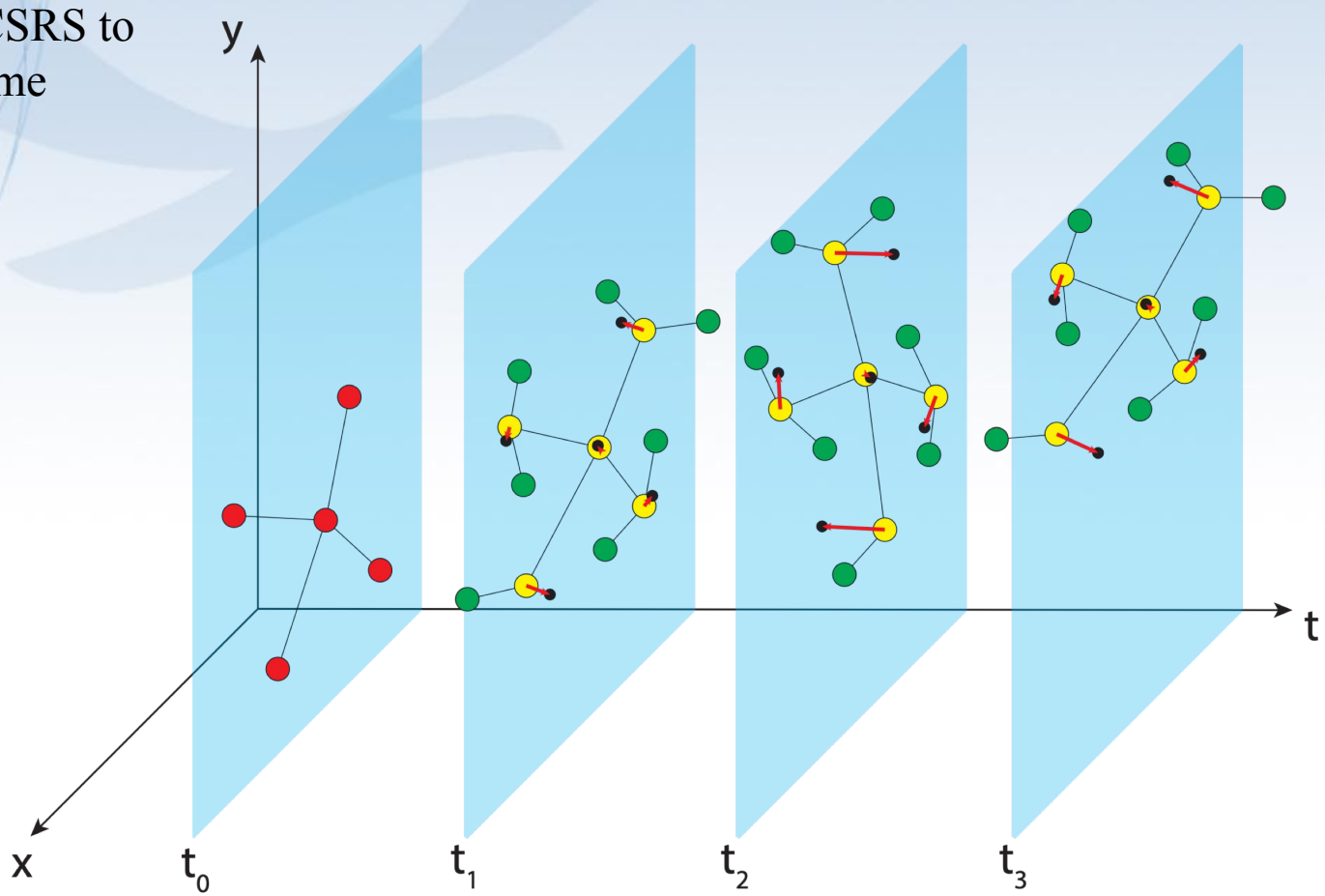

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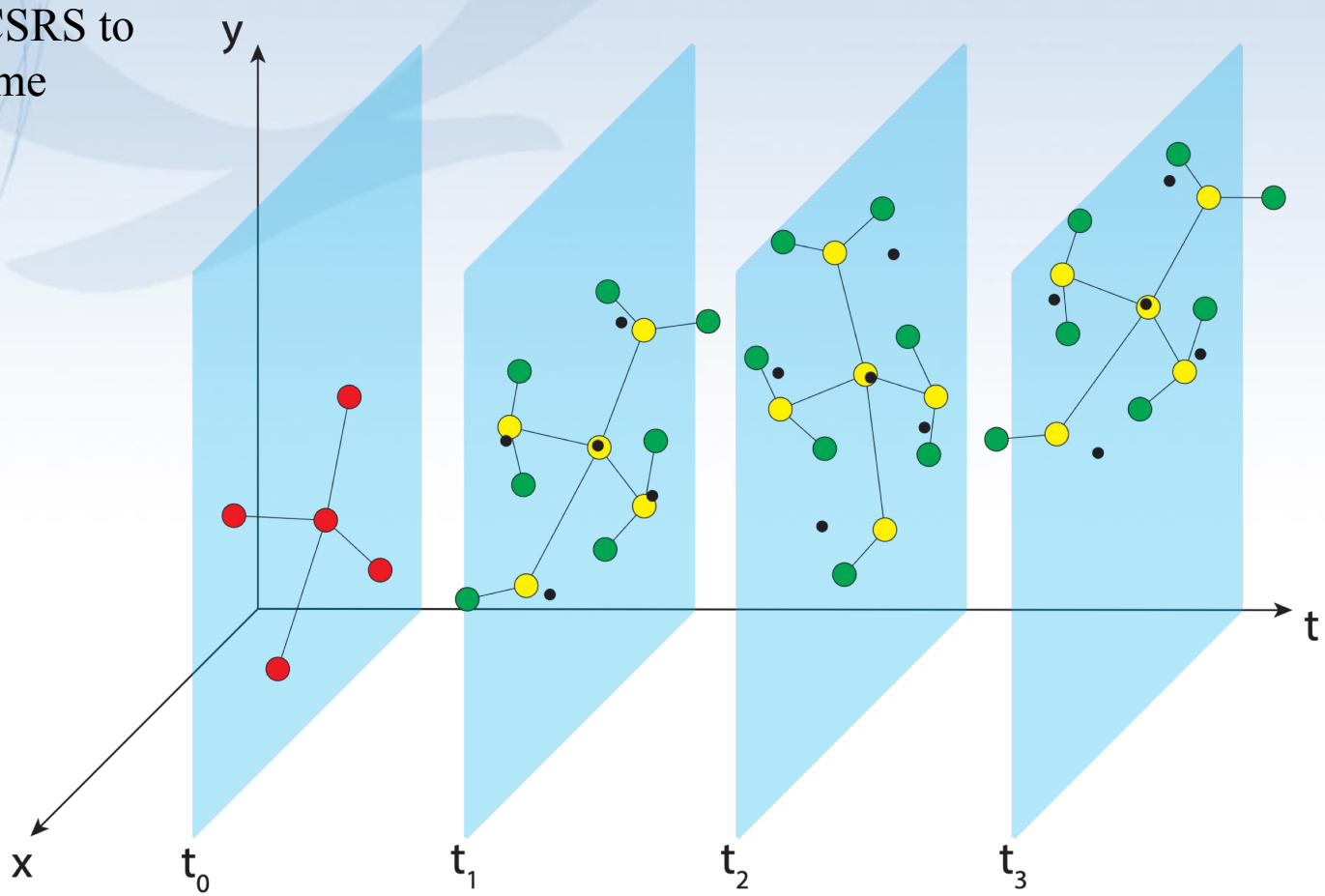

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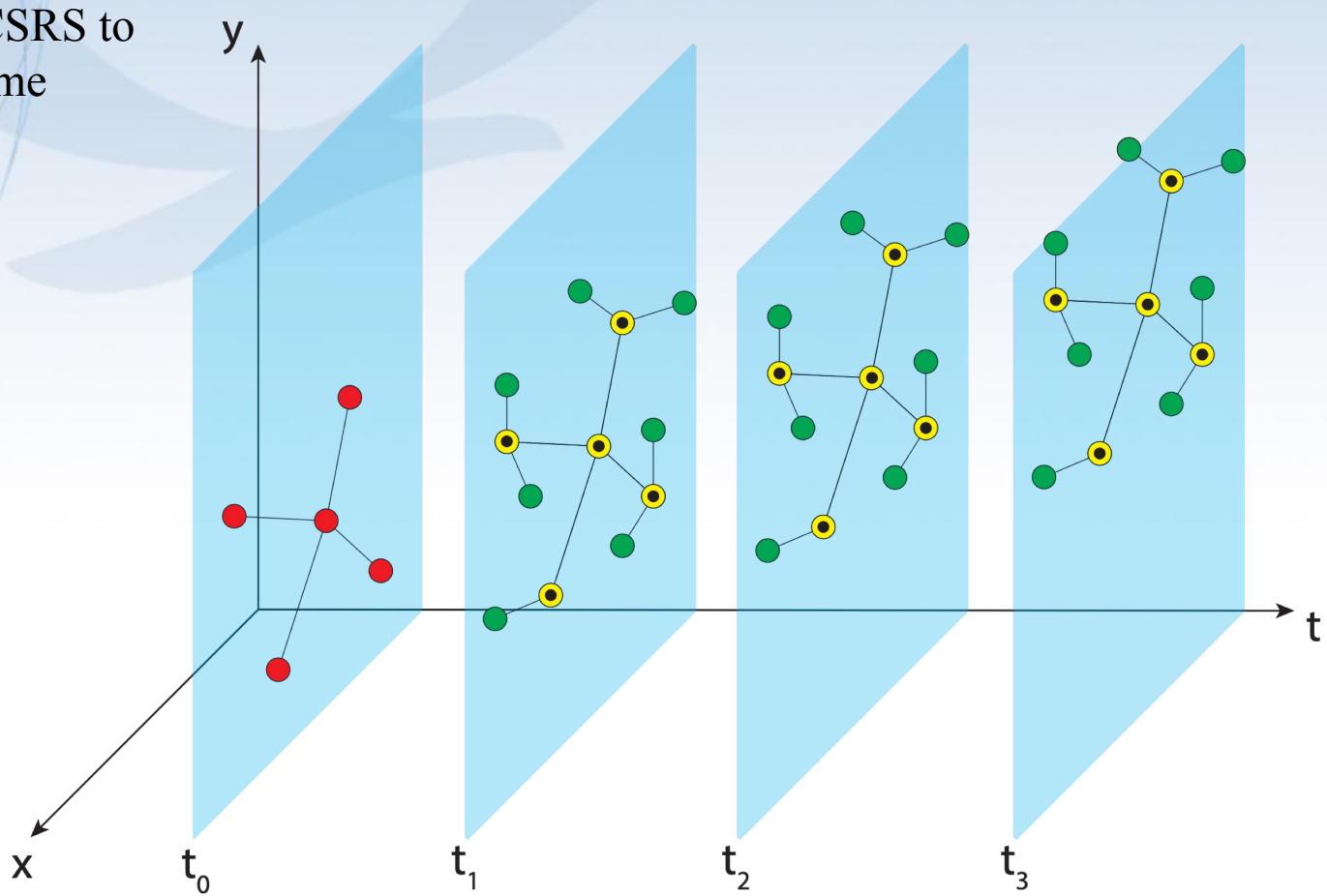

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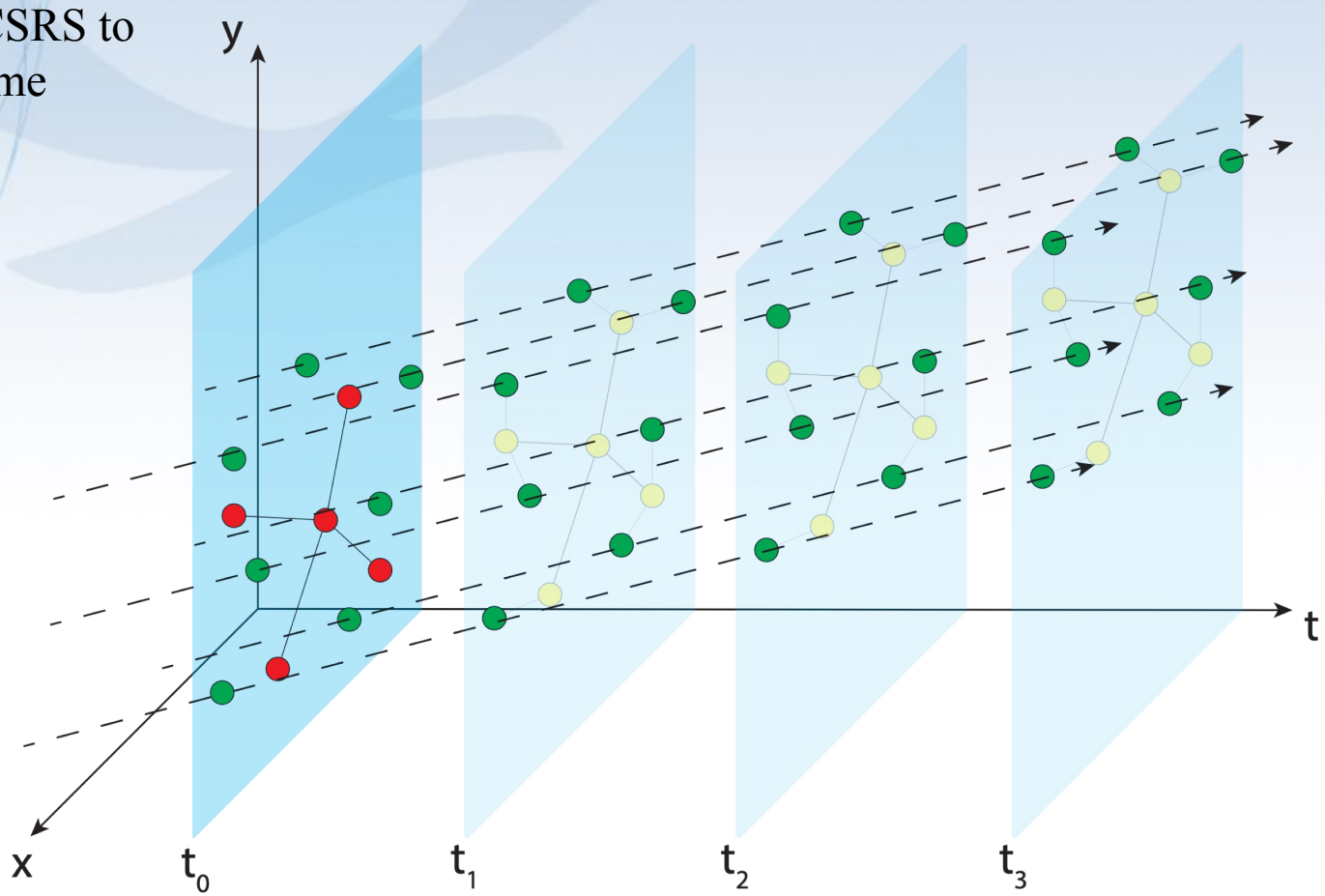

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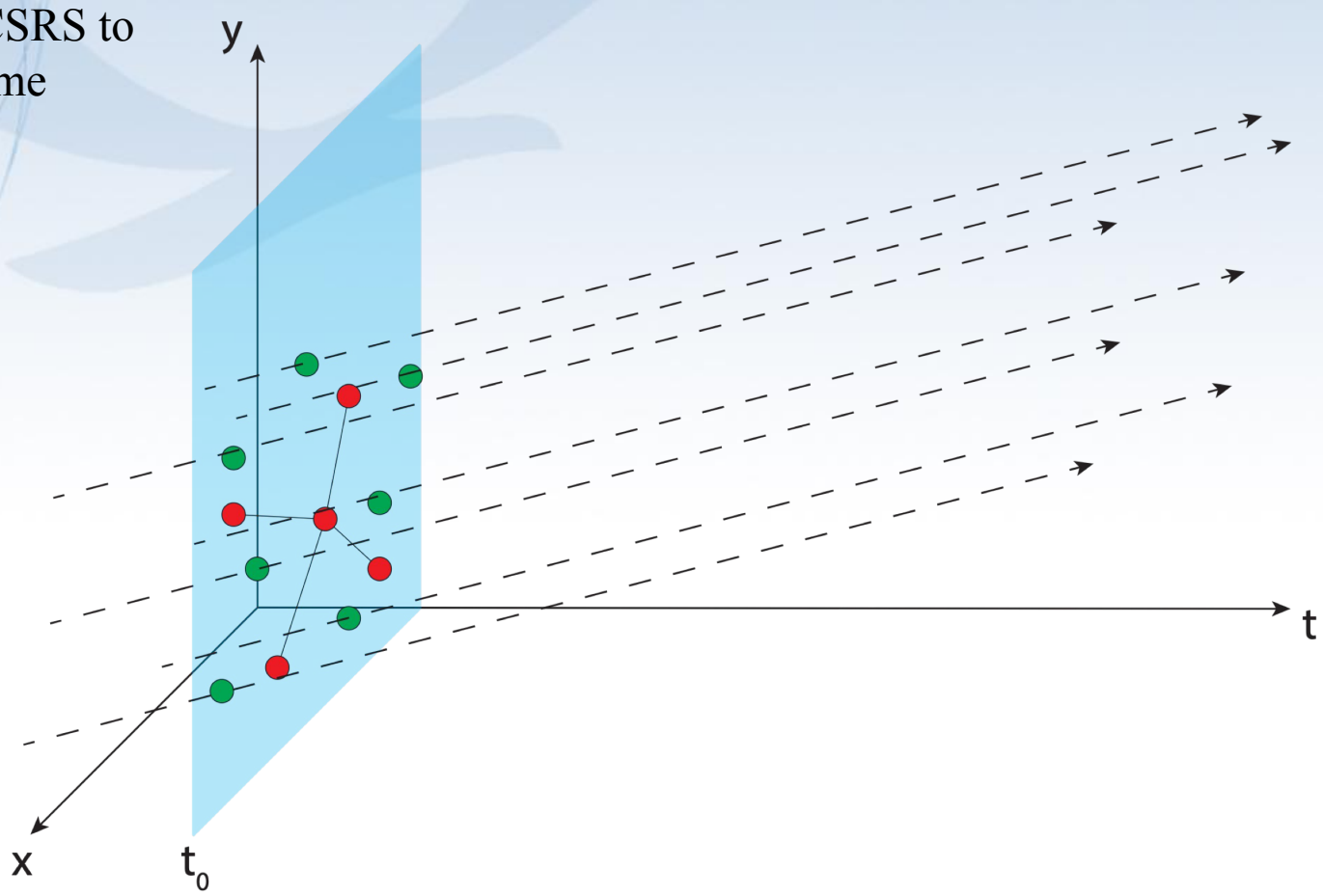

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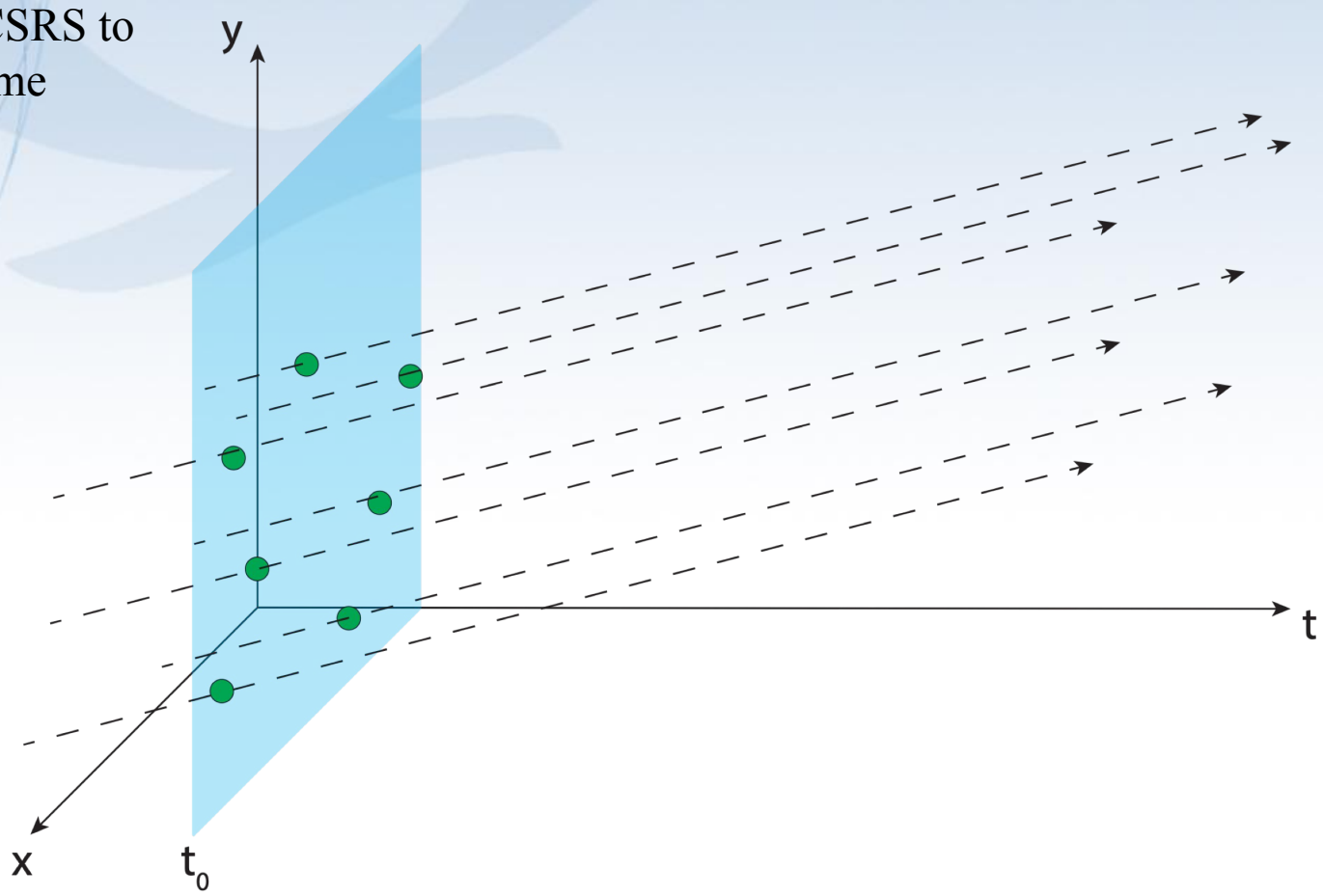

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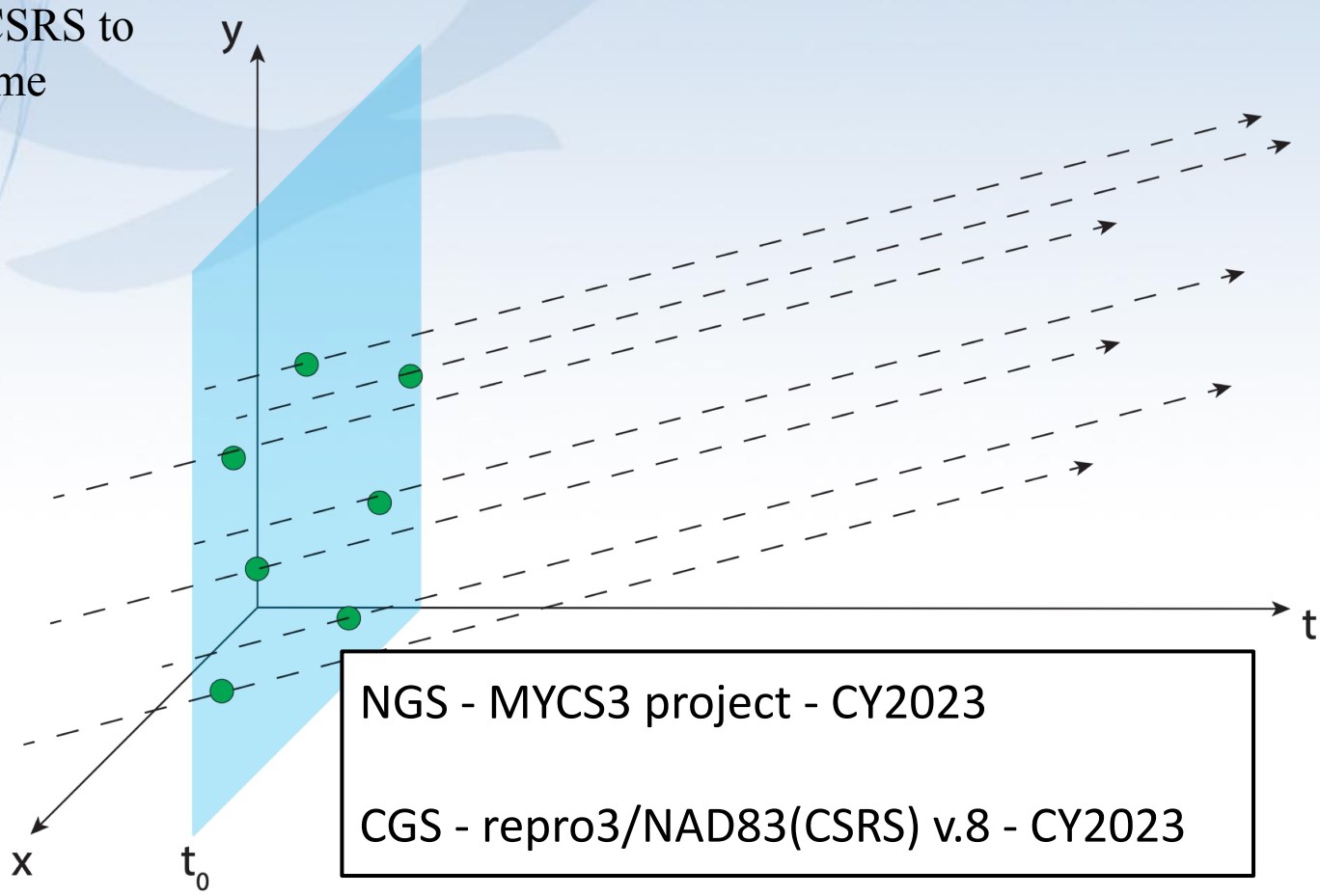

NGS - MYCS3 project - CY2023

CGS - repro3/NAD83(CSRS) v.8 - CY2023

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Consistency between the NSRS and CSRS

- Use common GNSS stations near the U.S.-Canada border for comparison
- Use the same antenna change and earthquake information for shared stations
- Use the same N. American Euler pole

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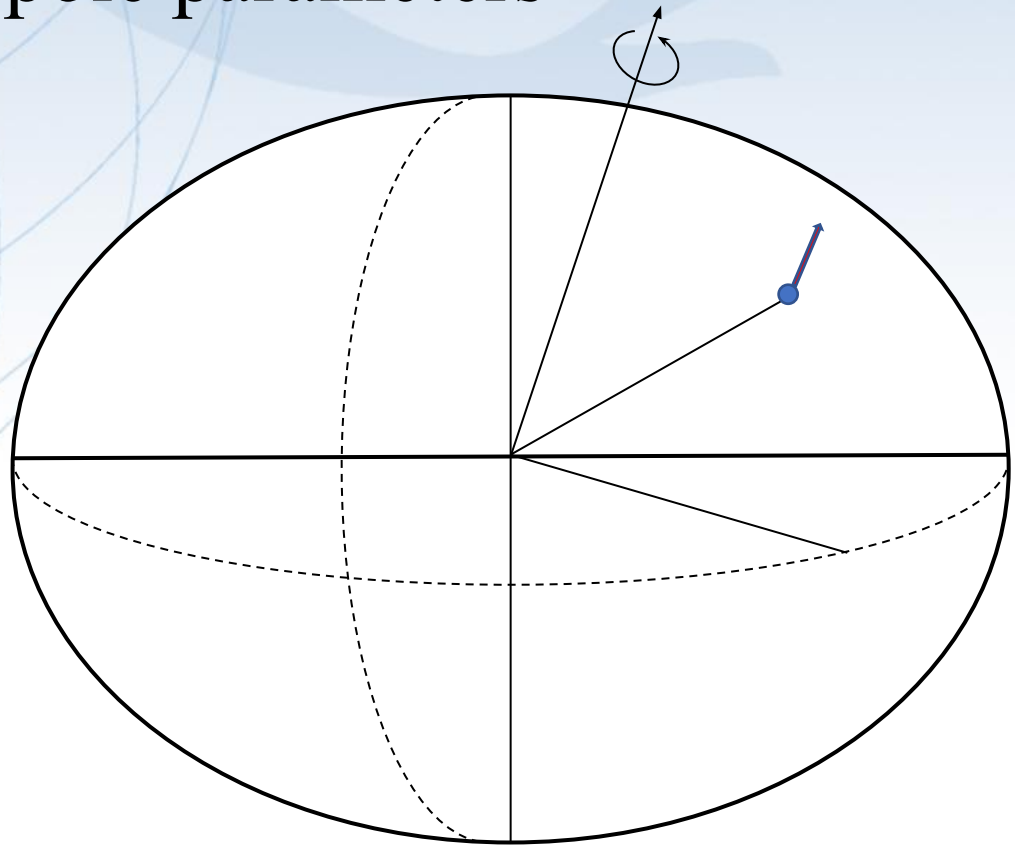
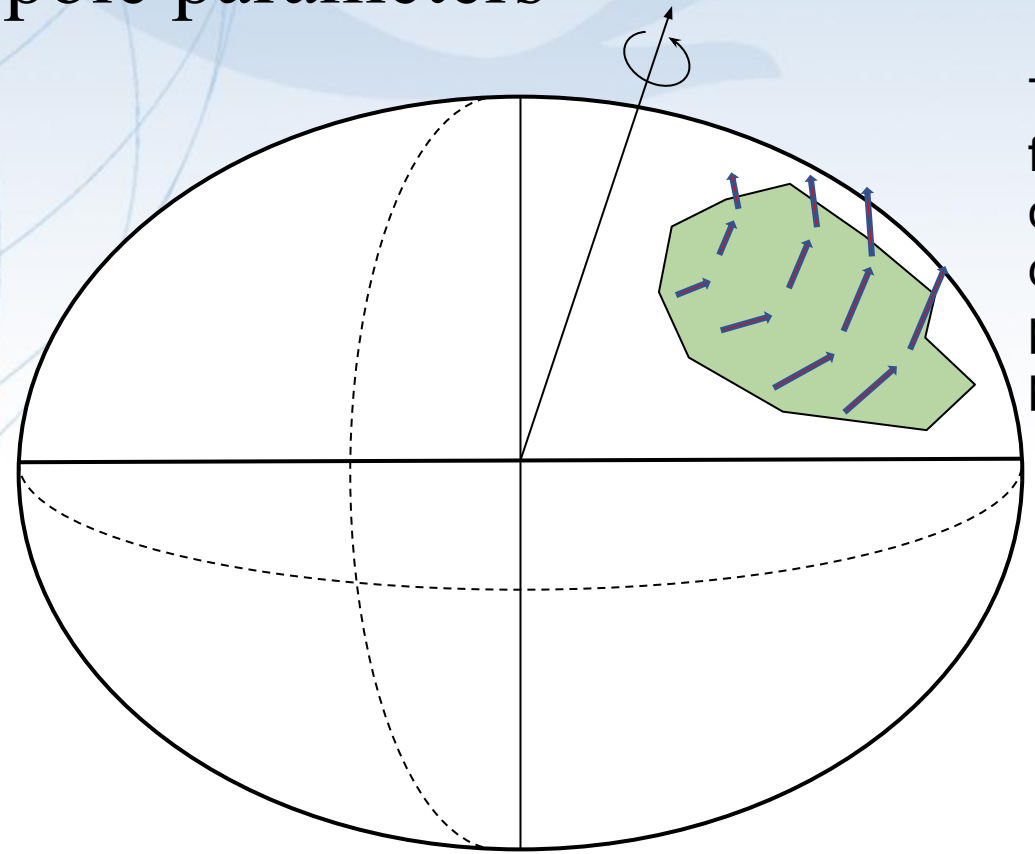
Euler pole parameters



The motion of a point on the surface of the Earth can be described by a right-handed rotation pole originating at Earth's center with three parameters.

Euler pole parameters



The motion of many points fixed to the same rigid body on Earth's surface can all be described by a single Euler pole with the same three parameters!

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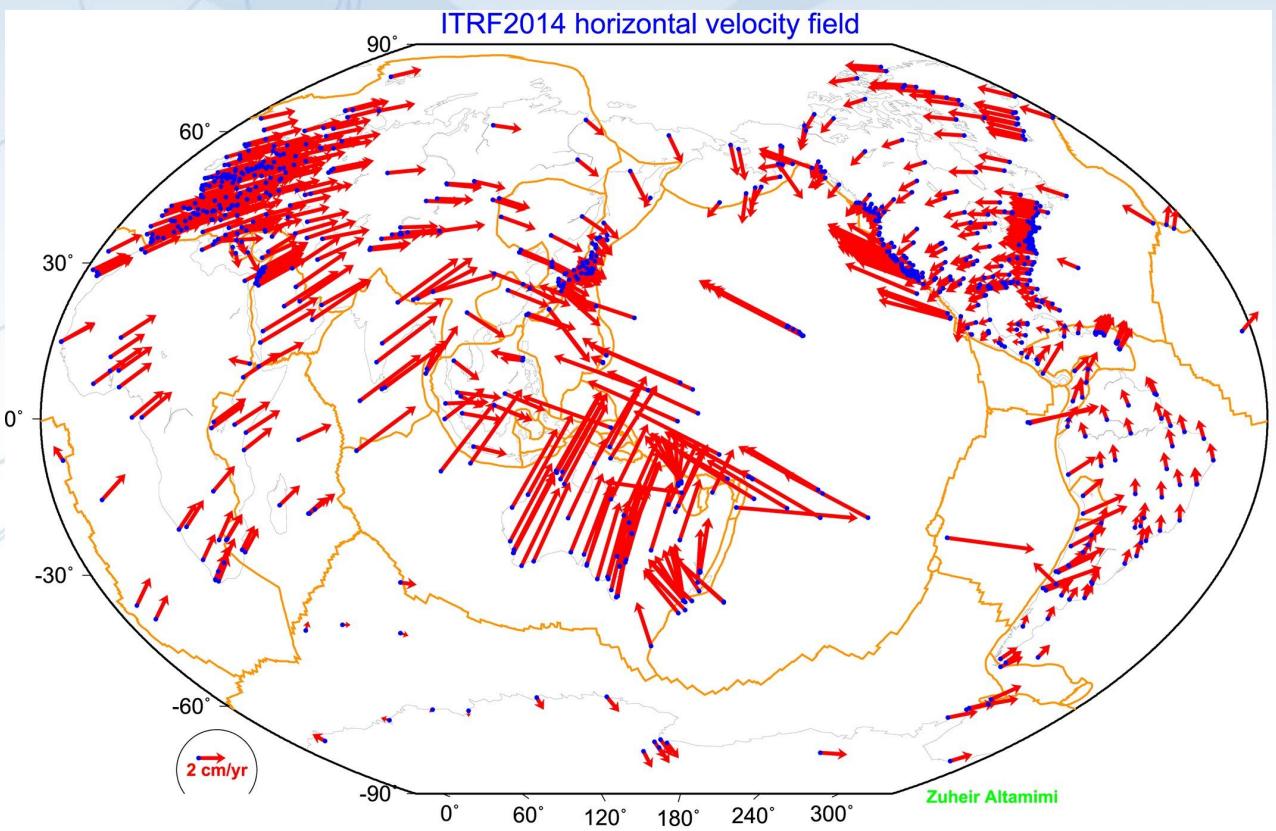
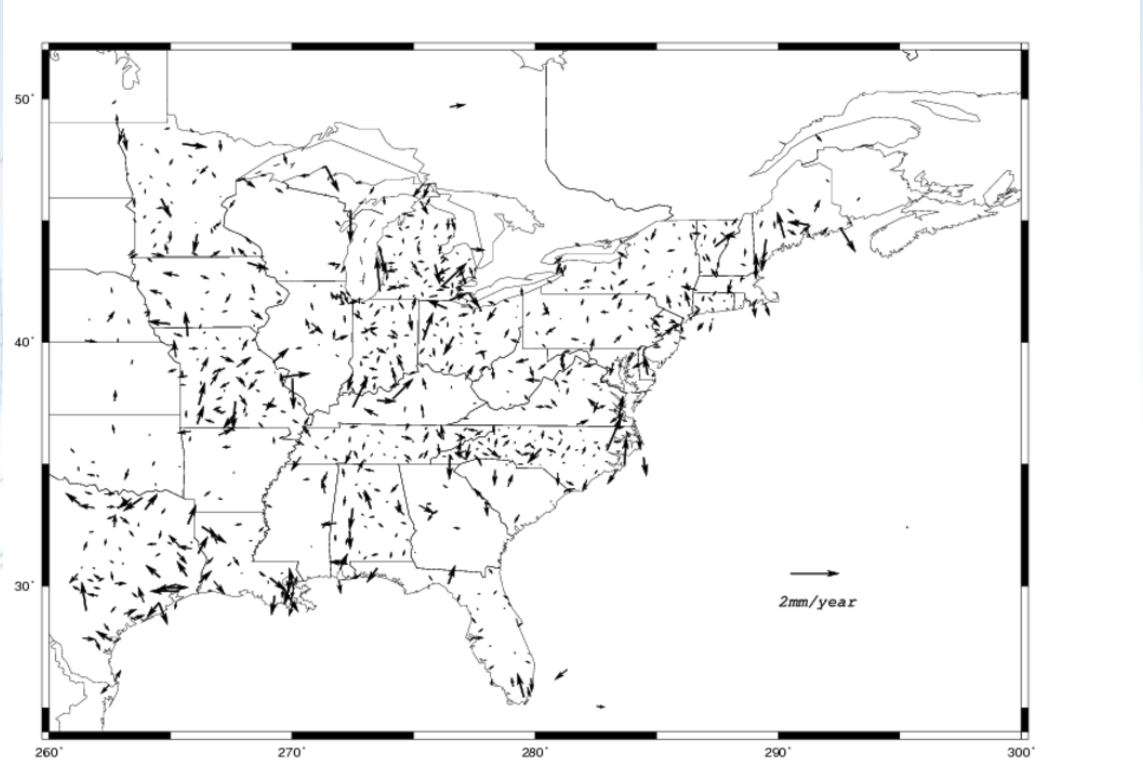


The ITRF velocity field very closely resembles absolute plate motion.

To transform from the ITRF to a plate-fixed frame you must remove the velocity contribution from plate motion => Euler poles

Altamimi et al., 2016, JGR

Getting from the ITRF to a plate-fixed frame



After plate rotation is removed there should be no rotation pattern in the observed velocity field.

Jarir Saleh, MYCS2, personal communication

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Getting from the ITRF to a plate-fixed frame

- NGS and CGS will have several choices for the ITRF => N. America Euler pole:
  - Altamimi et al. have published global Euler poles for each previous ITRF
  - Kreemer et al. have developed a method for separating strain from rigid plate rotation and have applied it to N. America
  - NGS and CGS will each estimate their own Euler poles
- NGS and CGS will work together to select a shared N. American Euler pole that suits both our stakeholders
  - Selection will be a convention for the modernized NSRS/CSRS

Thank you!