

DORIS

DAYS
2025

November, 3 and 5

DORIS Data Processing and Products

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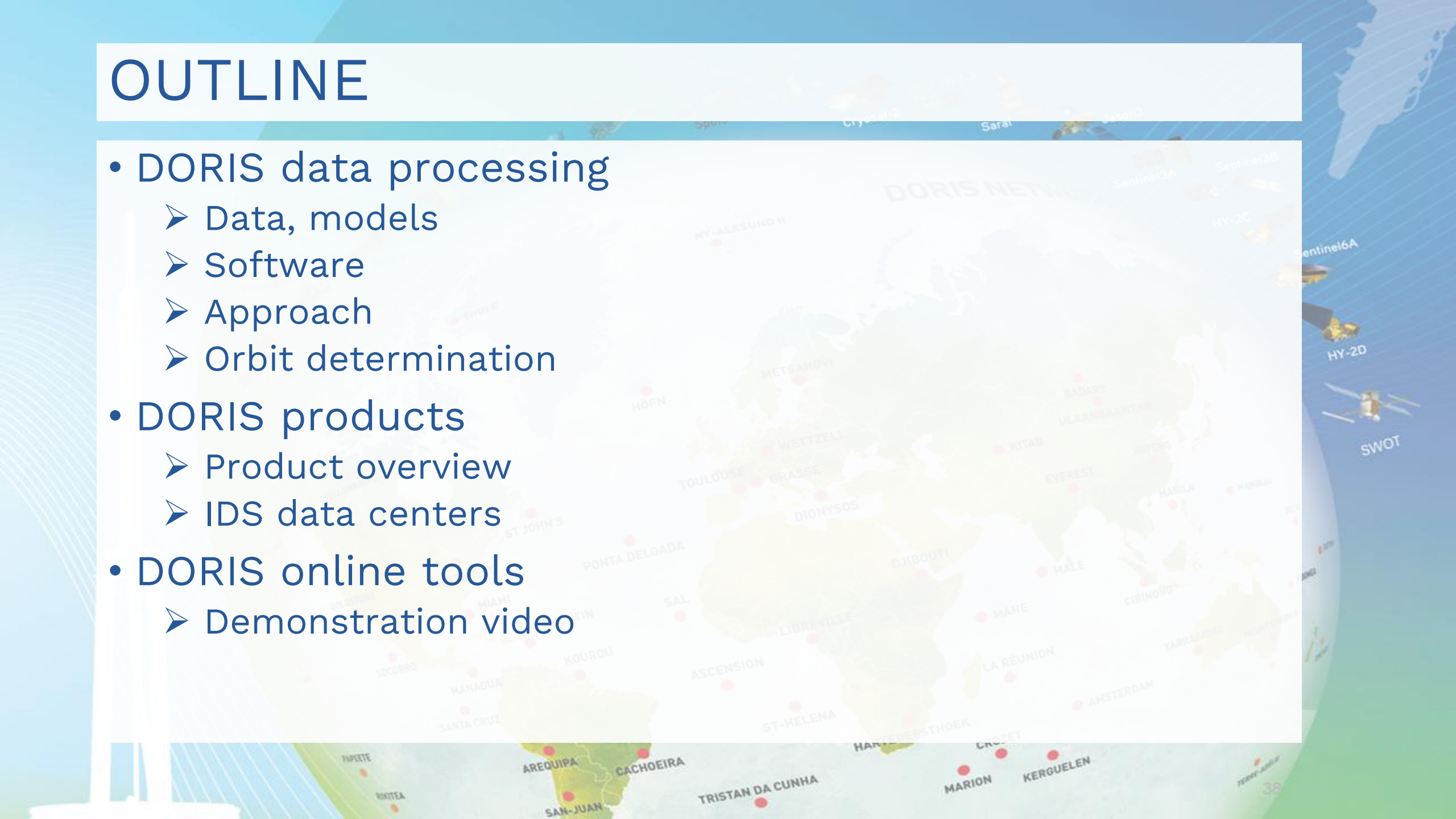
November 03

Session 1 – Presentation 2



OUTLINE

- DORIS data processing
 - Data, models
 - Software
 - Approach
 - Orbit determination
- DORIS products
 - Product overview
 - IDS data centers
- DORIS online tools
 - Demonstration video



DORIS data (observations) - formats

- DORIS exchange format

- “Old” format
- Not supported for new satellites
- Only format for older satellites (1st and 2nd generation of receiver)
- Not so closed to raw measurement
- Only one frequency measurement – range rate (+ionosphere correction from the file to be applied)
- No pseudorange measurement

- DORIS RINEX format

- “New” format
- Only format for most of recent satellites
- Closer to raw data
- Both frequencies measurement (phase)
- Pseudorange measurement available

https://ids-doris.org/documents/BC/data/RINEX_DORIS.pdf



Auxiliary data for DORIS processing

- Measured satellite attitude
 - Star trackers
 - Quaternions format
- Satellite nominal attitude models
- Satellite macromodels
 - Geometrical approximation of satellites (X-plates)
 - Optical properties of the plates
- Changes in satellite center of mass and total mass
- Maneuver information
- DORIS system events

External models to be applied

- IERS conventions definitions and models
- Time variable gravity field model
- Ocean Tidal loading (station position)
- Ocean and atmosphere tides (gravity effects)
- Subdaily pole model
- Third bodies
- Geomagnetic and solar flux data (for atmosphere drag modeling)

DORIS processing software

Software	Techniques	DORIS		IDS AC	Language	Licence
Bernese software (mod)	(D)+G	Carrier Phase	Least-Squares	GOP	Fortran	Agreement with Bern (Commercial or Academic)
GEODYN	D+G+L+V	Carrier Phase, Doppler	Least-Squares	GSC	Fortran	Public (non-commercial)
GIPSY-X	D+G+(L)	Carrier phase	Kalman	IGN	C++ Python	Academic
GENS	D+G+L+V	Carrier Phase, Doppler	Least-Squares, Kalman	GRG	Fortran	Academic
NAPEOS	D+G+L	Carrier Phase, Doppler	Least-Squares	ESA	Fortran	Academic or Commercial
EPOS-OC	D+G+L+V	Integrated Doppler count	Least-Squares	GFZ	Fortran	Academic

Methods for parameter estimation

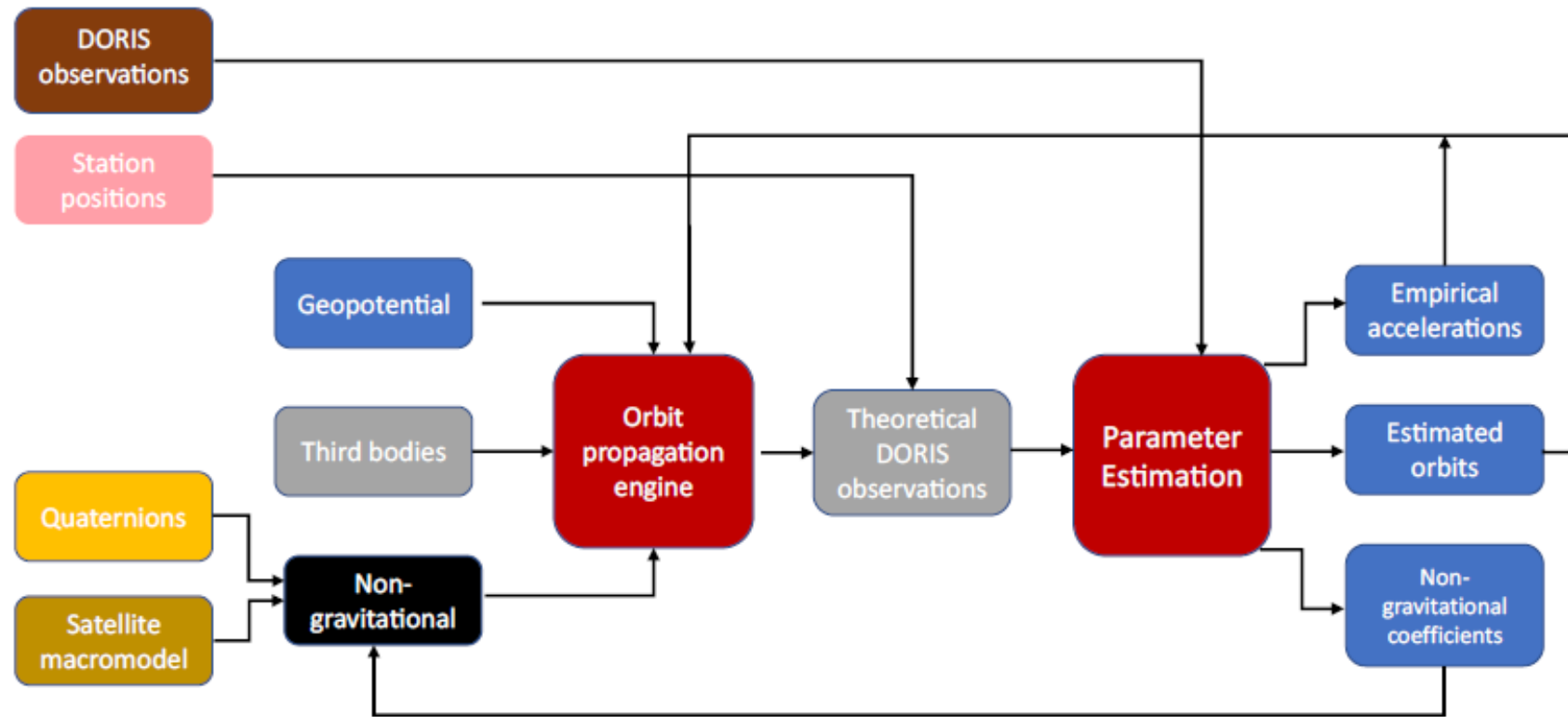
Batch least squares

- Collect all data
- Solve it in one run
- Deal with satellite pass parameters (frequency, troposphere)
- Iteration (linearization)
- Typically for post-processing

Kalman filtering

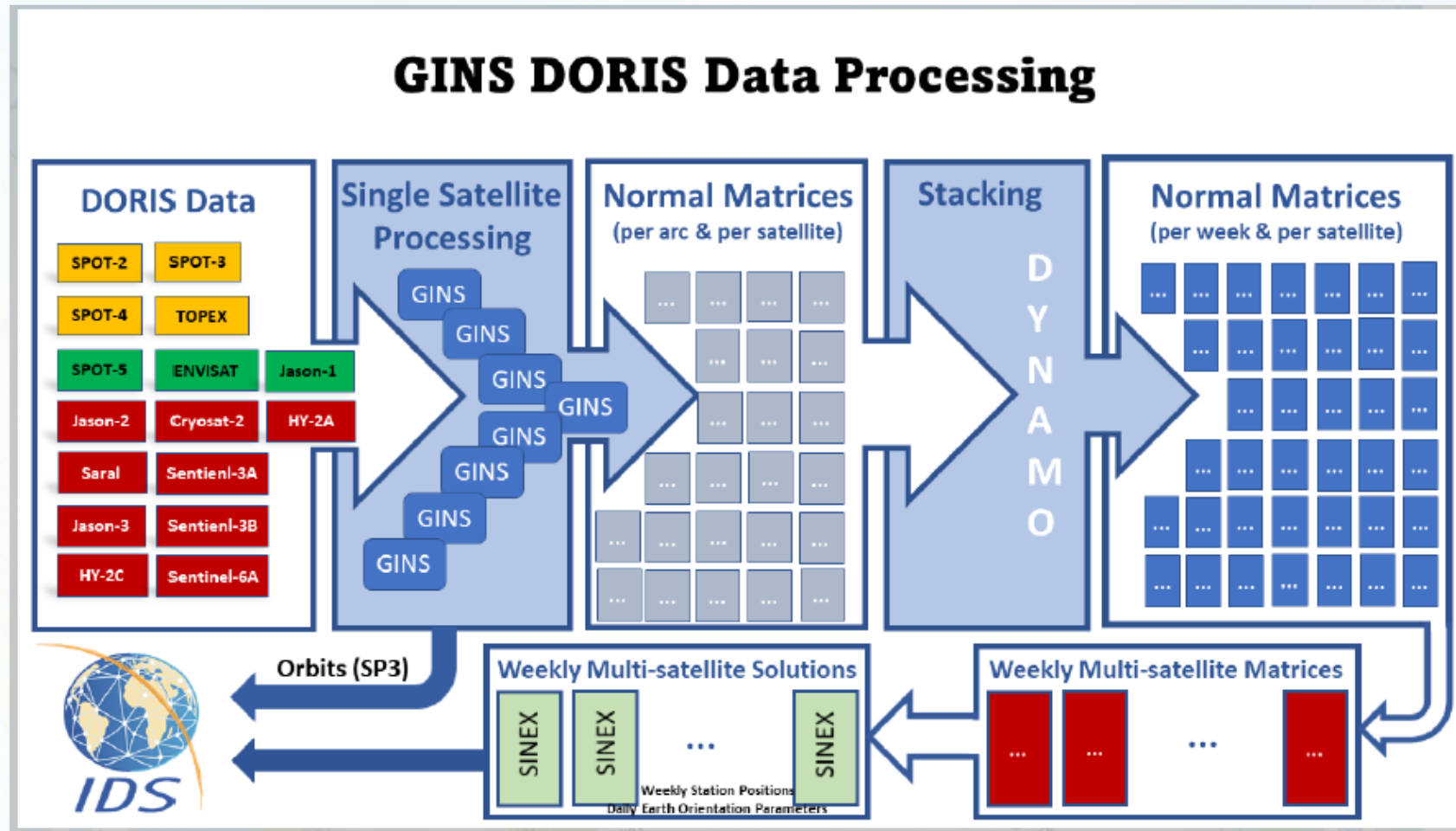
- Progressively collect input data
- Process it at the same time step
- Accumulate information for parameters that are solved later
- Typically (but not only) for NRT processing

DORIS POD chart



Source: <https://ids-doris.org/documents/CapacityBuilding/DorisDays2021/DD2021-S2P02-SoftwareProcessing.pdf>

DORIS data processing in Gins software



Source: <https://ids-doris.org/documents/CapacityBuilding/DorisDays2021/DD2021-S2P02-SoftwareProcessing.pdf>

IDS products (1)

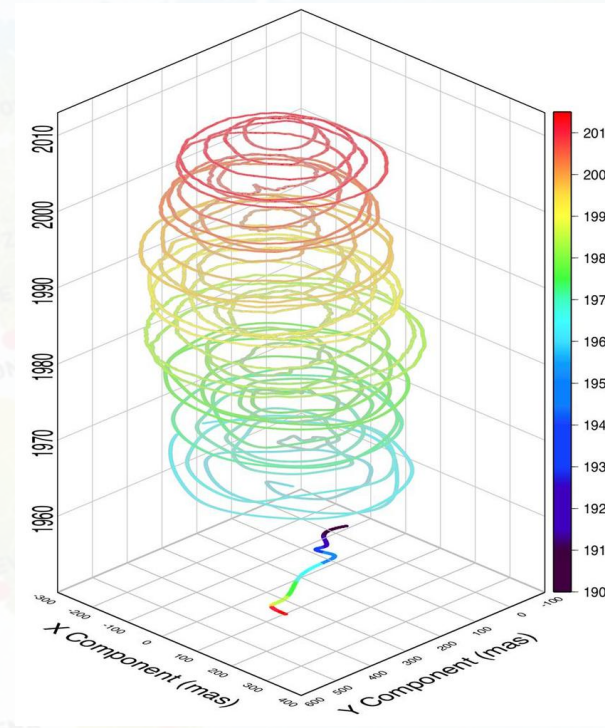
- SINEX files
 - NEQ or COV matrix, and more
 - Individual analysis center
 - combined IDS solution
 - weekly and cumulative
- Satellite orbits
 - (near) real time vs POD (higher accuracy = delay)
 - DORIS only vs multi-technique
 - DIODE – real time orbit
 - CNES POE orbits as the reference
 - SP3 orbit format as common standard (position and velocity records)

IDS products (2)

- Station coordinates
 - Weekly values
- Reference Frame for precise orbit determination (DPOD)
 - For POD
 - Based on cumulative solution
 - Coordinates and velocities
 - Updates 1-2 a year
 - Compatibility with last version of ITRF
 - <https://ids-doris.org/user-corner/combination/dpod.html>

IDS products (3)

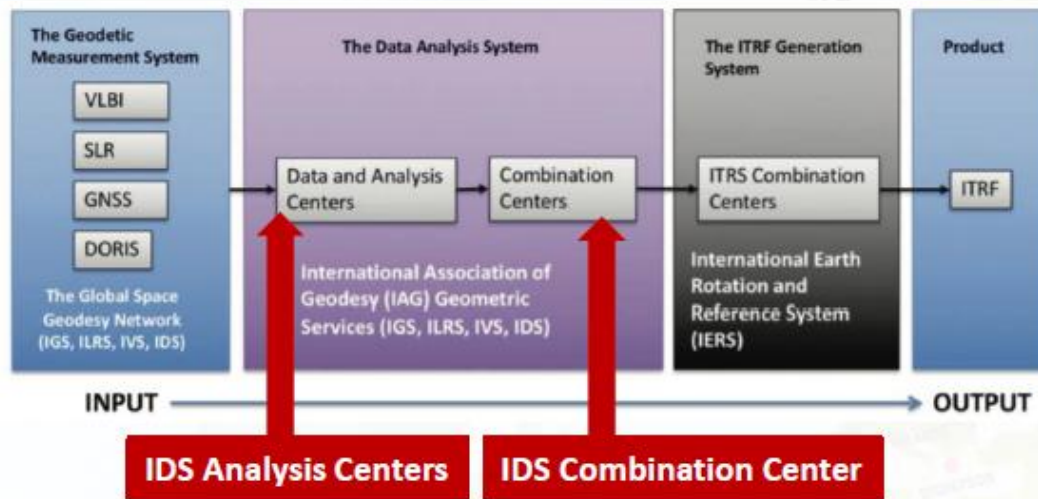
- Geocenter
 - Tx, Ty, Tz
 - Most accurate solution only based on Jason orbit satellites
- Earth Rotation parameters
 - Pole coordinates Xp,Yp, experimentally LoD
 - Daily values
- Ionosphere



Source: Pavlis et al., 2015

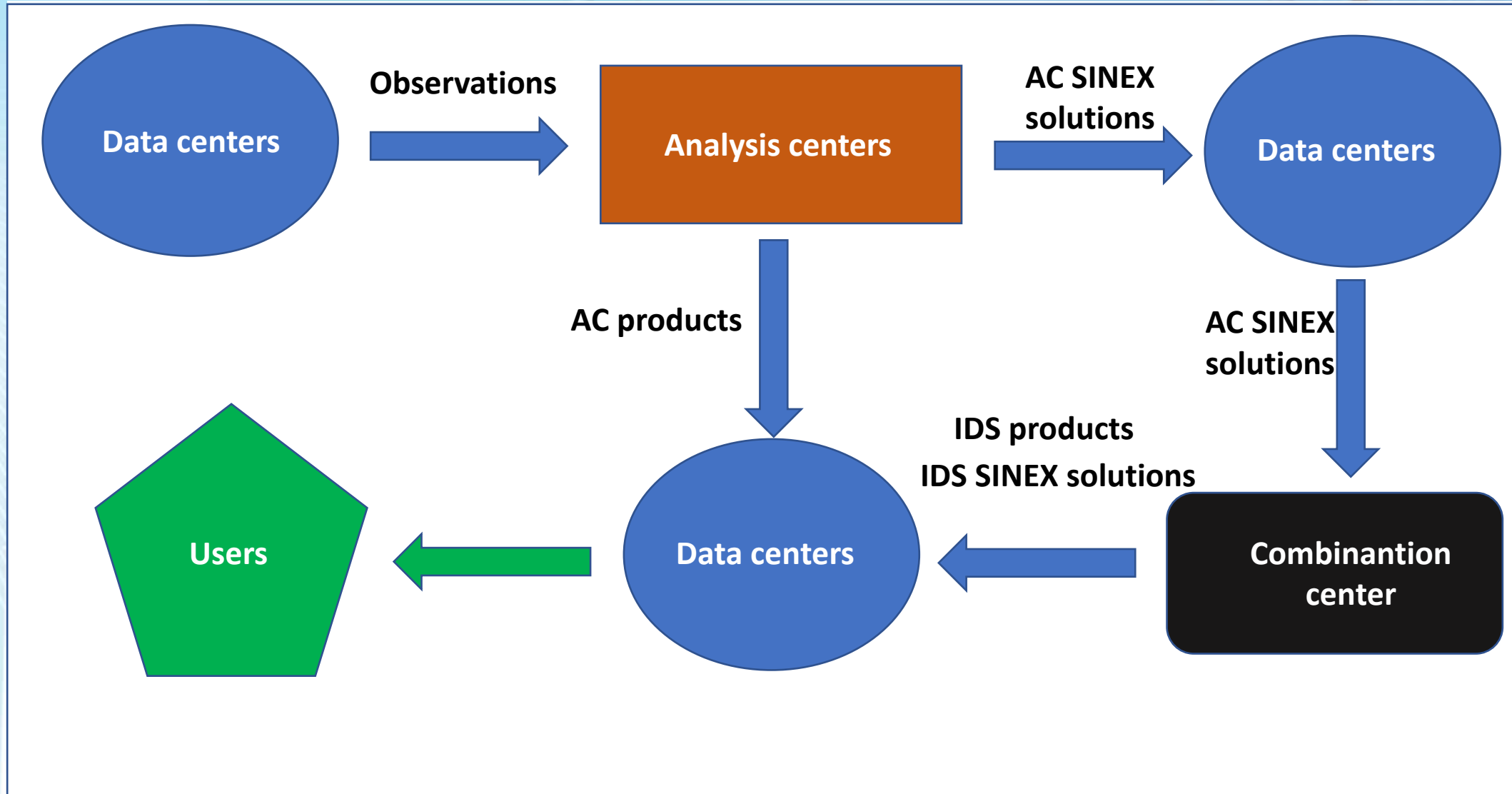
IDS contribution to ITRF

- DORIS –one of four space geodesy techniques involved
- IDS solution delivered to the IERS
- Multi-technique combination



Reference:
Figure 1.5,
Evolving the Geodetic Infrastructure to Meet
New Scientific Needs (2020),
National Academy of Sciences, 2020,
doi: 10.17226/25579

IDS products – IDS centers



IDS Data Centers

- two main Data Centers: CDDIS and IGN

- CDDIS

- root: <https://cddis.nasa.gov/archive/doris/>
 - Requires Earthdata account
 - Currently may give warning of US shutdown
 - Contact: *support-cddis [at] earthdata.nasa.gov*

- IGN

- Root: <ftp://doris.ign.fr/pub/doris/>
 - Contact: *ids.data.center [at] ign.fr*
 - The structure of both DC's is equivalent
 - General description at <https://ids-doris.org/ids/organization/data-centers.html>



IDS Data Centers - structure

in detail at <https://ids-doris.org/images/documents/Data-Structure-Formats.pdf>



- Data/ doris data
 - [sss]/[sss]data[arc].[lll].Z – preprocessed data (“Doppler”)
 - Example: *data/cs2/cs2data808.001.Z*
 - Single frequency with applied ionosphere correction
 - For (older) satellites cs2, en1, h2a, ja1, ja2, sp2, sp3, sp4, sp5, srl, top
 - doris.files – contains preprocessed data timespans
 - [sss]/[yyyy]/[sss]rx[yy][ddd].[lll].Z –raw data (“RINEX”)
 - Example: *data/cs2/2025/cs2rx25301.001.Z*
 - Dual frequency, closer to original measurements
 - For (newer) satellites cs2, h2a, h2c, h2d, ja2, ja3, srl, s3a, s3b, s6a, swo
 - In the example codes, “cs2” is the name of the satellite. Unlike GNSS, each observation file corresponds to a single satellite and a defined period (a day for Doppler, a cycle/arc for RINEX).

IDS Data Centers – structure (2)

in detail at <https://ids-doris.org/images/documents/Data-Structure-Formats.pdf>

- products/
 - sinex_global, sinex_series/ - combinations and resulting coordinates in sinex format
 - /[ign|lca|grg] – products of particular analysis centers
 - /ids/ - product of combination centre
 - Latest IDS product: *products/sinex_global/ids/ids22d01.snz.Z*
 - orbits/[grg|gsc|lca|ssa]/[sss]/[prod][sss]20[timespan].(...).sp3.[lll].Z – satellite orbits
 - Primary resource are ssa orbits that are available continuously
 - Example: *products/orbits/ssa/h2d/ssah2d20.b25271.e25281.DG_.sp3.001.Z*
 - dpod/ – coordinates for particular epochs (used as apriori for analysis)
 - *products/dpod/dpod2020_current.[snz/txt].Z*
 - lono/ - ionosphere products
 - eop/ - earth orientation parameters products
- ancillary/quaternions/[sss]/[yyyy]/[sss]q[body|solp][timespan].[lll] – quaternions
 - Satellites JA1, JA2, JA3 and SWOT



entinel6A

HY-2D

SWOT

PAPETE

AREQUIPA

CACHOEIRA

SAN JUAN

TRISTAN DA CUNHA

HARTBEESTHOEK

MARION

KERGUELEN

TERRE-AUGER

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DORIS Data Centers – other resources

- Data table overview:
<https://ids-doris.org/data-products/tables-of-data-products.html>
- Further data necessary for processing at Doris Central Bureau page
<https://ids-doris.org/documents/BC/satellites/>:
 - Satellite mass
 - [sat]mass.txt
 - Maneuvers
 - [sat]man.txt
 - Attitude files
 - [sat]att.txt
- Resources in <https://dataspace.copernicus.eu/> :
 - Quaternions for S3A, S3A and S6A
 - CDSE login and custom scripts needed for automated download
 - Product to be found is AUX_PROQUA

Key points

- Recent data format RINEX
- Various processing software tools
 - Least squares or Kalman filter
 - typically stepwise process (observation processing -> normal equation combination)
 - Another step, IDS combination stacking SINEXes from all analysis centers
- IDS products
 - SINEX files, station coordinates, DPOD, satellite orbits, EOPs, and more
- Satellite orbit determination
 - DIODE – real time
 - POD
 - DORIS only and multi-technique
- IDS contribution to ITRF
- IDS components involved
 - Data centers, analysis centers, combination center