

# Rigorous combined IERS products - Introduction -

**Manuela Seitz and Detlef Angermann**

Deutsches Geodätisches Forschungsinstitut (DGFI)  
Centrum für Geodätische Erdsystemforschung (CGE)  
München



# Outline

## 1. Consistency of the IERS products

- Is there a need for consistent solutions of ITRF, ICRF and EOP ?
- Is there a need for a simultaneous day-to-day estimation of EOP and combined station positions?

## 2. Combination procedures

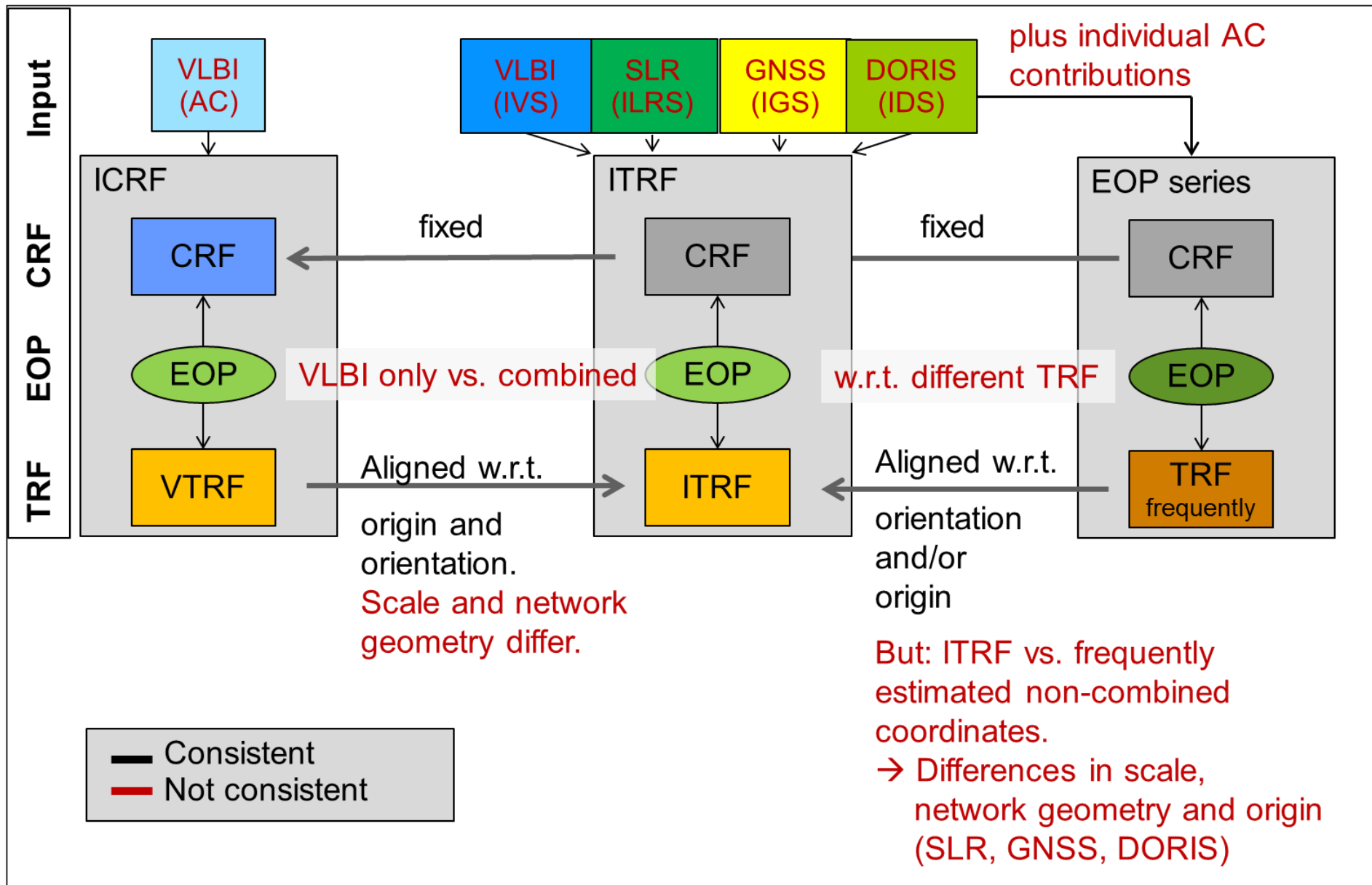
- How rigorous the applied combination procedures are?
- Is there a need for a rigorous combination at the observation level?

# 1. Consistency of the products

- Today, IERS provides ICRF, ITRF and EOP.
  - The products are generated by different groups using different softwares and input data.
- The products are not fully consistent.
- With respect to the GGOS requirements regarding accuracy and consistency of the geodetic products, there might be a need for consistent ITRF-ICRF-EOP solutions.

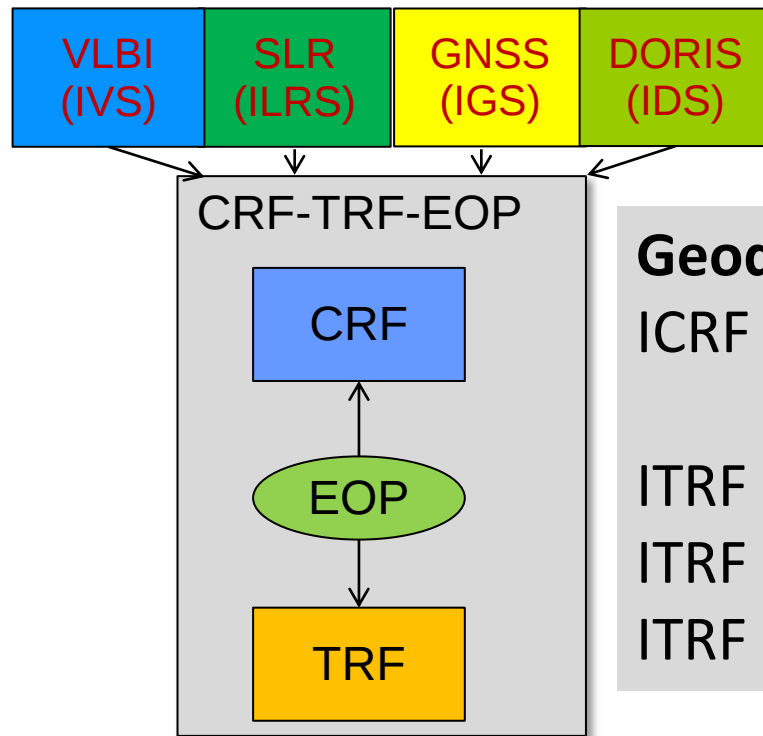
**IUGG resolution 3 adopted in 2011:** “highest consistency between the ICRF, the ITRF, and the EOP as observed and realized by the IAG and its components such as the IERS should be a primary goal in all future realizations of the ICRS. “

# 1. Consistency of the products: overview



# 1. Consistency of the products

Consistency can be reached by estimating CRF, TRF and EOP in one adjustment



## Geodetic datum:

ICRF orientation: NNR w.r.t. previous solution

ITRF origin: SLR

ITRF scale: VLBI+SLR

ITRF orientation: NNR w.r.t. previous solution

- Only minimum constraints are applied.
- No deformation due to datum realization.

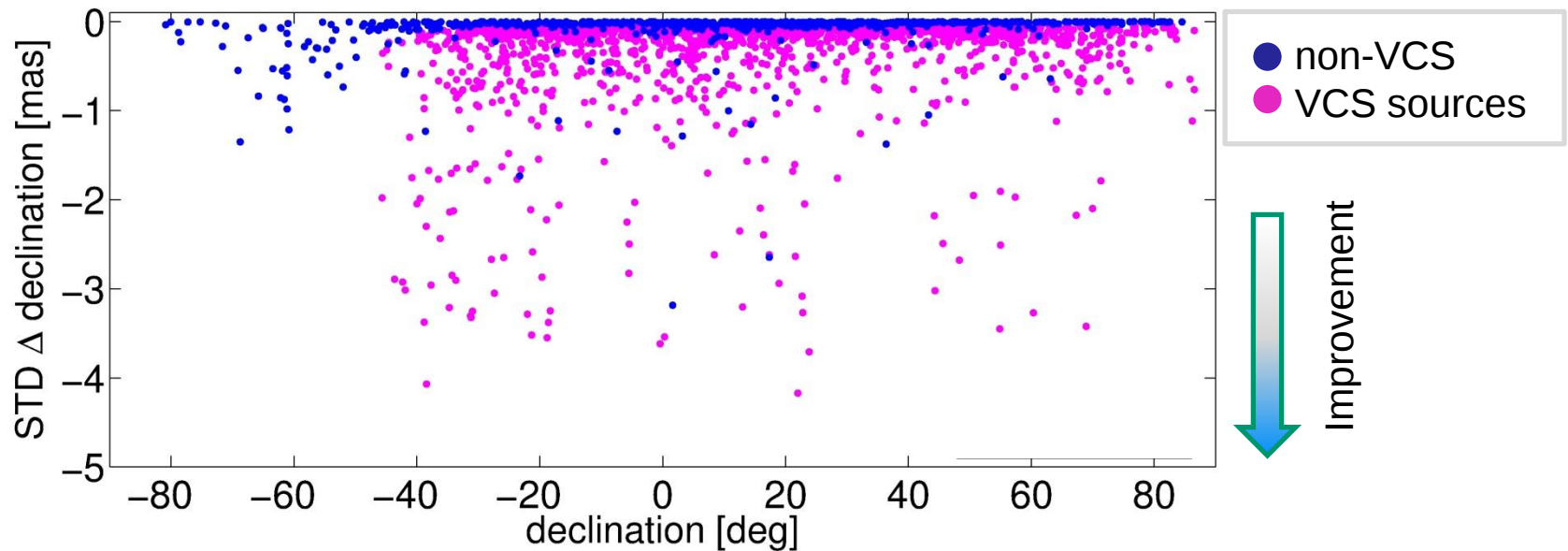
# 1. Consistency of the products: issues to be studied

## 1.1 Simultaneous estimation of ICRF, ITRF and EOP

- Consistency between the products will be reached.
- Questions: Does the ICRF benefits w.r.t.
  - Standard deviations? → *Yes [Seitz et al. 2012]*
  - Accuracy of positions (absolute)? → *Have to be investigated in detail!*
- Main challenge: the validation of the CRF
- Current activities: will be presented in detail by *C. Ma, C. Jacobs, R. Gaume*
  - IAG Sub-Commission 1.4 “Interaction of Celestial and Terrestrial Reference Frames”
  - IAU Working Group on ICRF-3

# 1. Consistency of the products: issues to be studied

Source positions: Change of the standard deviations due to the combination



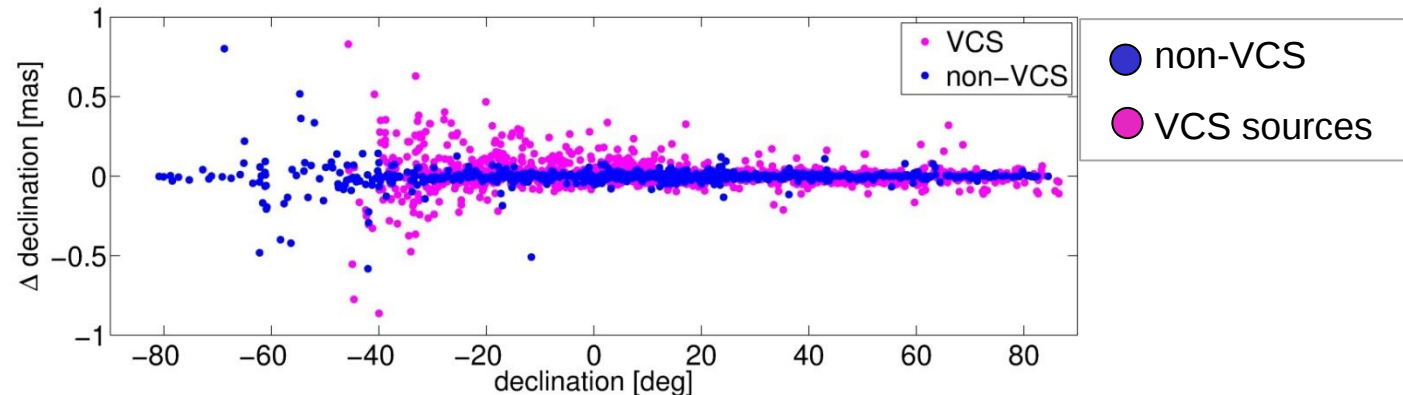
- Standard deviations decrease in general.
- Sources observed by VCS sessions only benefit most.
- About 90% of the decrease is caused by pole combination.

# 1. Consistency of the products: issues to be studied

## Source positions: Changes due to the combination

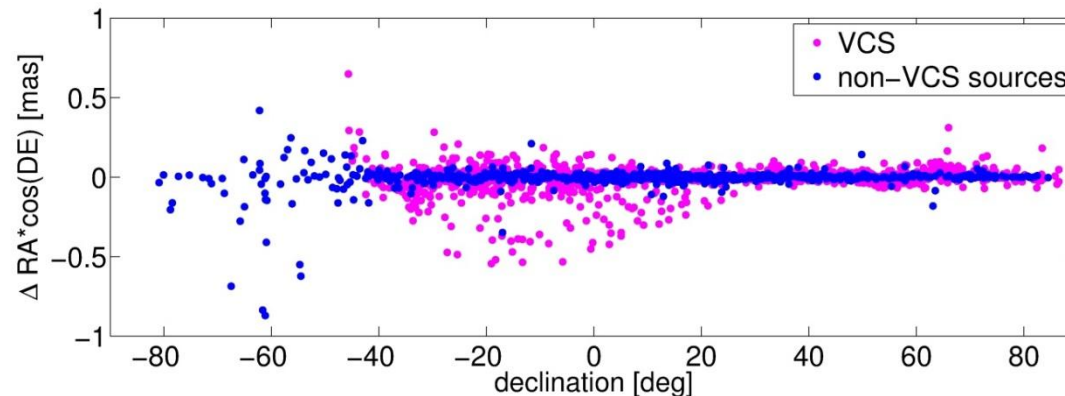
### Declination

w.r.t. VLBI-only  
[mas]



### Right ascension

w.r.t. VLBI-only  
[mas]



→ VCS sources are stronger influenced by the combination (improvement?).

→ The effect is dominated by LOD combination.

# 1. Consistency of the products: issues to be studied

## 1.2 Day-to-day simultaneous estimation of combined station positions (epoch reference frames) and EOP

- EOP, estimated simultaneously to highly resolved station positions, are – in contrast to ITRF related EOP – not affected by non-modeled non-linear effects in the station motions.
- Full consistency between ITRF/ICRF related EOP and the day-by-day EOP products cannot be reached in near future.
- However, a simultaneous estimation of combined station positions and EOP would provide:
  - Station networks more consistent to the ITRF regarding datum realization (origin by SLR, scale by SLR+VLBI, orientation alignment mainly based on GNSS network)
  - Consistency between station positions and EOP (for all techniques)

# 1. Consistency of the products: issues to be studied

## 1.2 Day-to-day simultaneous estimation of combined station positions (epoch reference frames) and EOP

Question: does the day-by-day-products (IERS C04) can benefit from a simultaneously estimation of combined EOP and station positions?

- Is the accuracy of combined station positions improved compared to the single-technique solutions provided by the TC?
- Can the EOP be improved by a simultaneous adjustment of EOP and combined station positions?
- If yes, what is the adequate temporal resolution for the station positions?

### Current activities:

- *presentation by D. Gambis & B. Luzum and by R. Gross*
- IAG JWG 1.3. „Strategies for epoch reference frames“ (with a main focus on reference frames)

## 2. Rigorous combination approaches

Current procedures applied for ITRF and EOP combination

| Products/<br>Research  | Combination<br>level            | Parameters combined                                               |      |     | Remarks                                                              |
|------------------------|---------------------------------|-------------------------------------------------------------------|------|-----|----------------------------------------------------------------------|
|                        |                                 | Station<br>coordi-<br>nates                                       | pole | LOD |                                                                      |
| <b>ITRF</b>            |                                 |                                                                   |      |     |                                                                      |
| IGN                    | Solution level                  | X                                                                 | X    |     | Differences in local tie<br>handling and weighting                   |
| DGFI                   | NEQ level                       | X                                                                 | X    | X   |                                                                      |
| <b>EOP series</b>      | Solution level                  |                                                                   | X    | X   |                                                                      |
| <b>IERS WG<br/>COL</b> | Observation<br>and NEQ<br>level | X<br>additionally: orbits, nutation<br>rates, tropospheric param. | X    | X   | Combination at<br>observation level is the<br>most rigorous approach |

Publication on the different combination levels: *[Seitz et al., accepted]*

## 2. Rigorous combination approaches

### Current procedures applied for ITRF and EOP combination

- From the theoretical point of view differences between all three combination strategies exist.
- With respect to the increasing precision of the technique observations and the developments regarding a higher consistency of the IERS products, the different strategies should be applied and tested by IERS in the future.

### Current activities:

The IERS WG on the Combination at the observation level deals with the combination at the observation and the normal equation level and the comparison of the individual results.

→ *Presentations by R. Biancale and D. Thaller*

# Summary

Main issues to obtain rigorous combined products:

- Input data:
  - Identical or at least consistent data sets
  - SINEX files containing either normal equations or solutions with full variance-covariance matrices (like, e.g., for ITRF)
- Simultaneous adjustment of products (on multi-year and on daily/weekly basis).
- Investigations on the impact of the combination procedure on the combination results.

# Different combination strategies

## Pros

### Combination at the observation equation level (COL)

- Common outlier detection and Internal weighting of obs.
- Same modeling and parameterization by default

### Combination at the NEQ level

- A good approximation of COL, if modeling and parameterization are homogenized and all common parameters are combined

### Combination at the solution level

- Not very sensitive w.r.t. weak parameters

## Cons

- adequate software is required
- Large computational effort

- Outlier detection not based on all observations
- Large computational effort

- Full geodetic datum necessary for each input data file → Have to be removed in the combination (parameters of similarity transform.)
- → larger Operator-Software-Impact (OSI)

## 2. Rigorous combination approaches

Procedures applied currently for ITRF and EOP combination

The combination of different techniques can be performed at three different levels of adjustment: the observation, the normal equation and the solution (parameter) level [*Seitz et al., accepted*]:

- The IERS EOP series are generated by applying the combination at the solution level.
- The ITRS realizations are performed by
  - Combination at the solution level (IGN)
  - Combination at the normal equation level (DGFI)
- Combination at the observation level is not yet applied for IERS product generation, but IERS WG COL is performing investigations regarding the combination at the observation level.

→ *Presentations by R. Biancale and D. Thaller*

## 2. Rigorous combination approaches

### Current procedures applied for ITRF and EOP combination

- Only for the ITRF products, comparisons are performed so far (e.g. Seitz et al. 2013).
  - However, the differences between the solutions ITRF2008 and DTRF2008 are also influenced by other aspects (differences in the weighting of the techniques, the handling of the local ties and the EOP combination).
- Thus, at the current stage, the impact of the different combination strategies on the ITRF cannot be quantified easily. Specific investigations are necessary.