

Using DORIS for modeling the Vertical Total Electron Content of the Earth's Ionosphere

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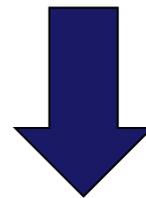
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Motivation

DORIS measurements are influenced by free electrons in the Earth's ionosphere

This ionospheric effect can be computed by using both DORIS signals (f_1 and f_2)



DORIS should be capable to provide useful information for ionosphere modelling

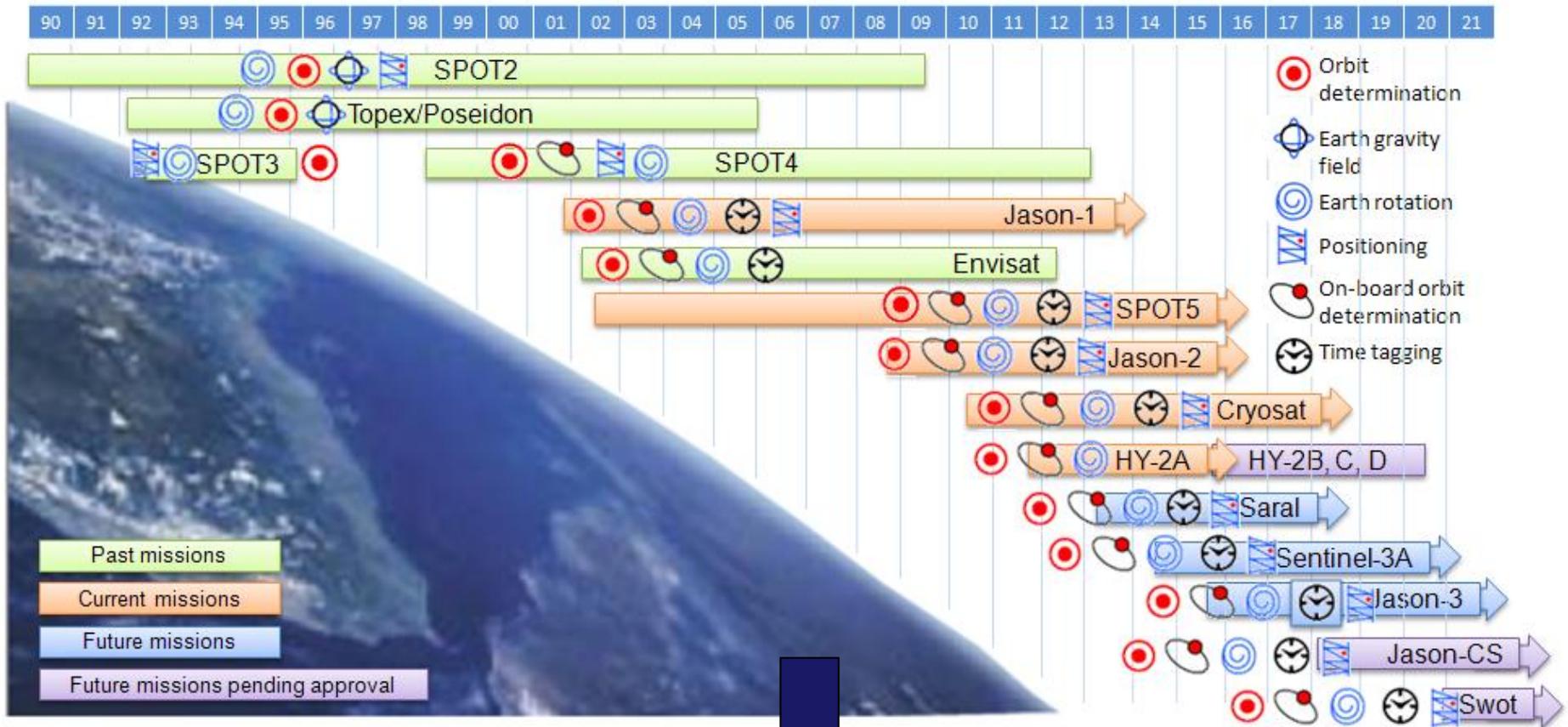
Content

- DORIS data distribution
- Pre-processing of DORIS data
- Validation of DORIS VTEC
- Global VTEC model approach
- Results: VTEC models based on different observation types
- Conclusion and Outlook

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- ❑ **DORIS data distribution**
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DORIS data distribution: missions



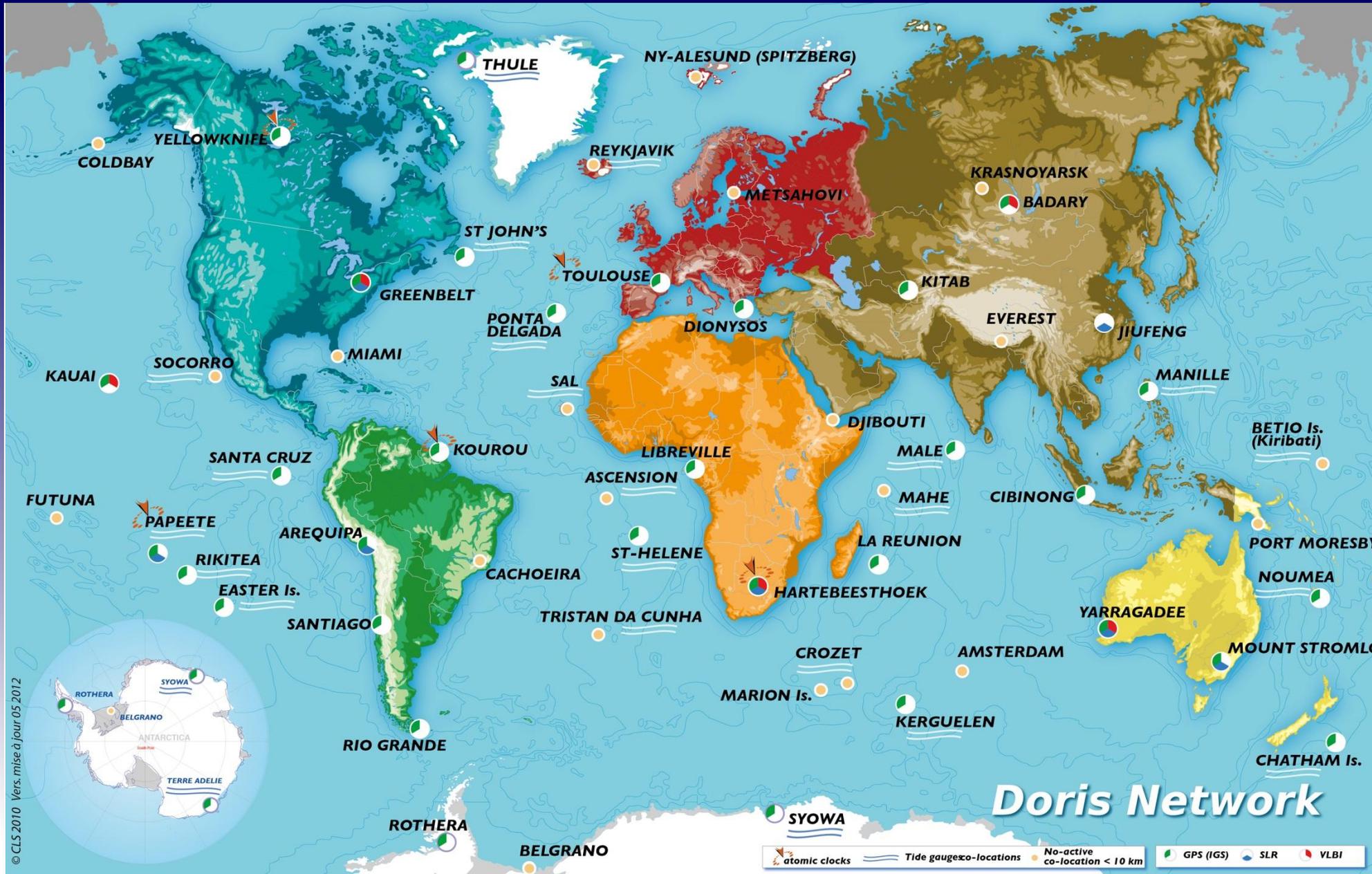
Credits: CLS/Cnes



currently: 4 missions with DGXX receiver
Jason-2 / Cryosat / HY-2A / Saral

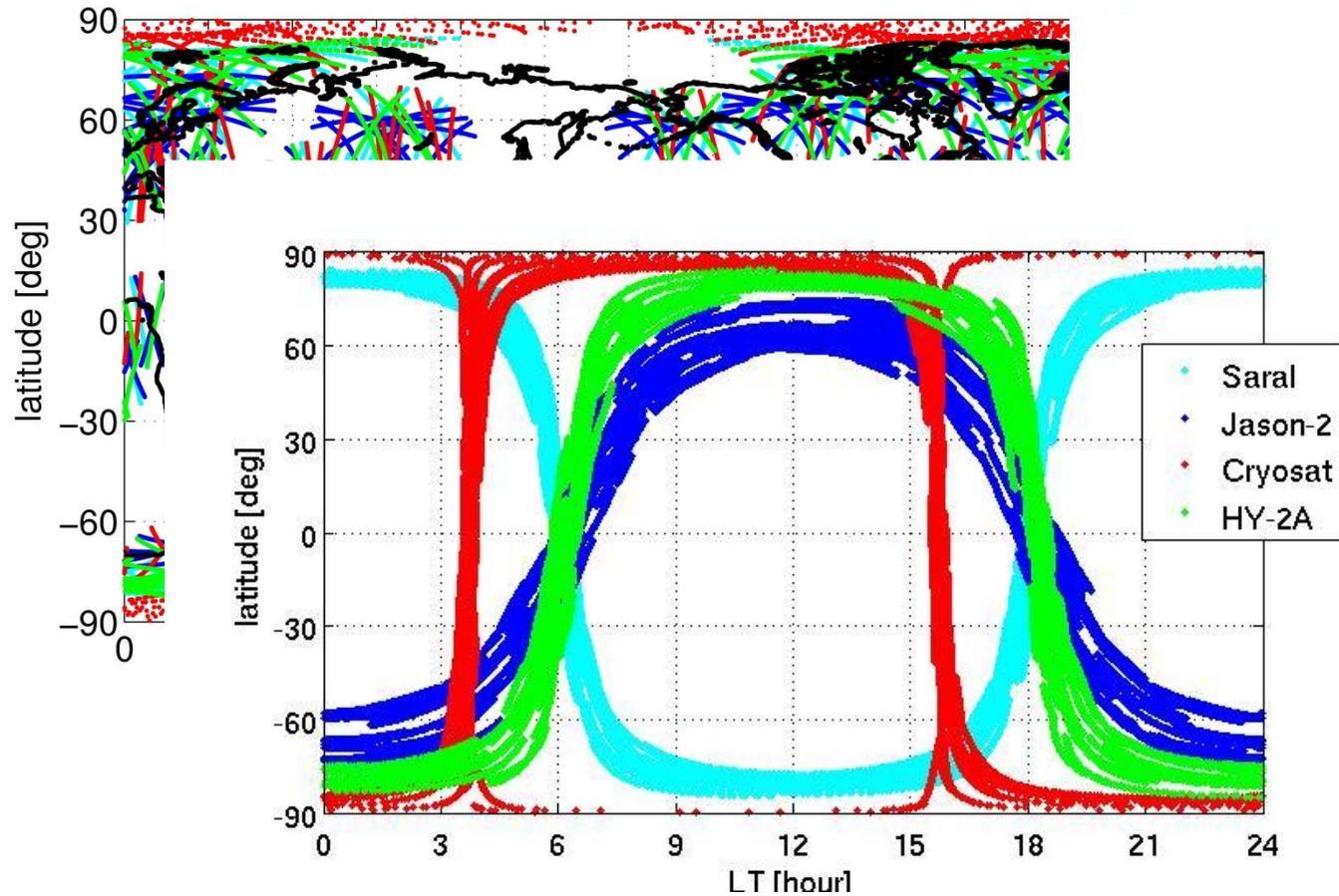
DORIS data distribution: ground beacons

IDS Workshop 2014, 27/28.10.2014



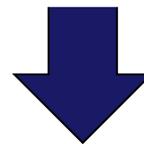
DORIS data distribution (24h)

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sun-fixed
reference system:

no uniform
distribution due to
sun-synchronous
orbits of HY-2A
and Saral



Data distribution is not sufficient to derive DORIS-only global ionosphere models for each day of the year !

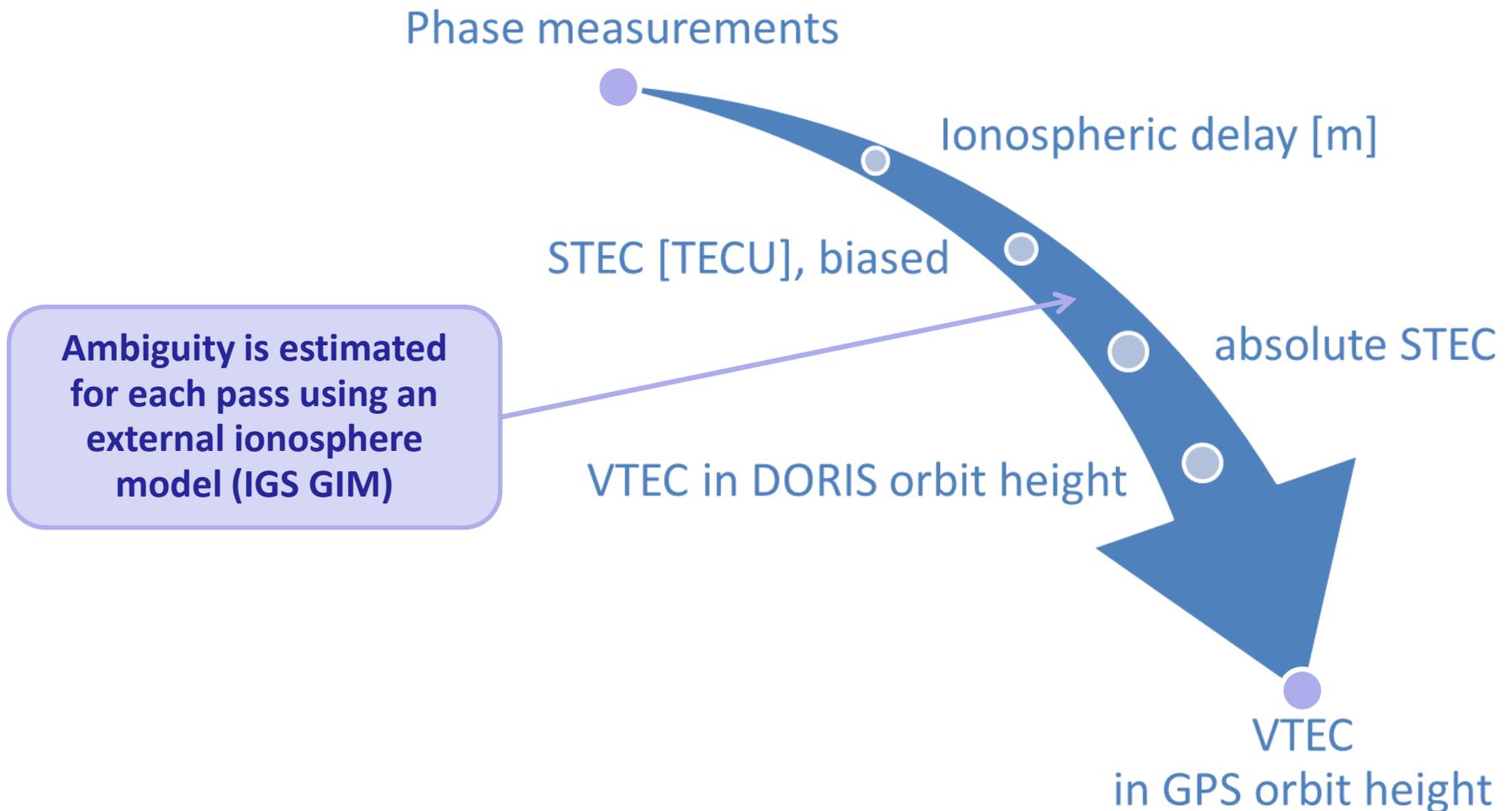
 However: might be useful in combination with other measurement techniques 7

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DORIS data preprocessing

Method is similar to classical GNSS preprocessing, with one major difference:
No reliable code measurements are available!



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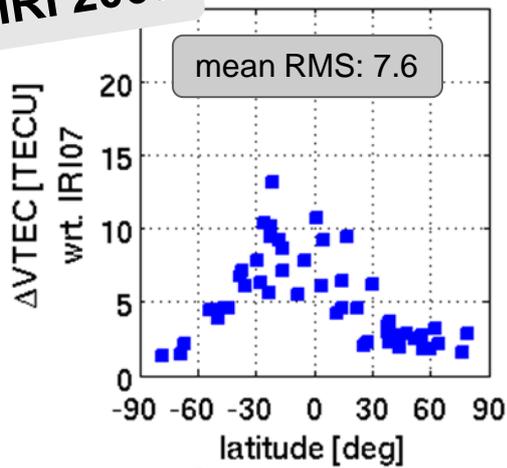
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DORIS VTEC validation

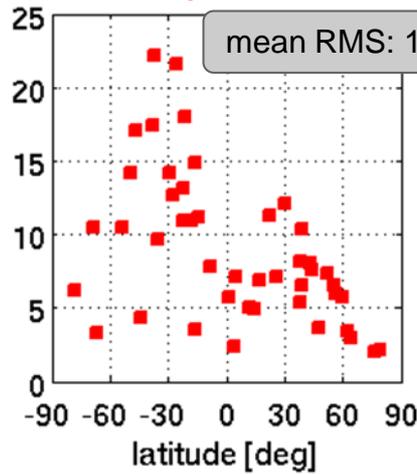
RMS of differences to global ionosphere models (per station)
DOY 258/2013 (Sept 15, 2013)

IRI 2007

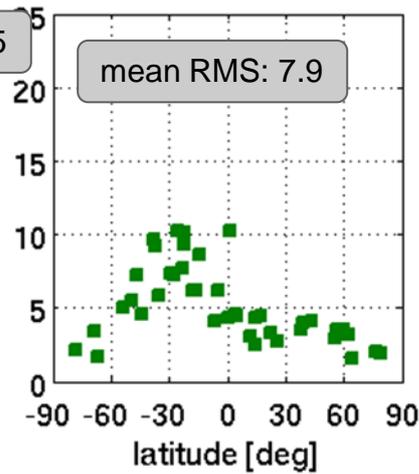
Jason-2



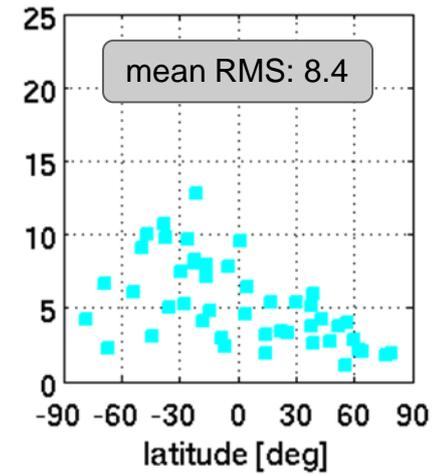
Cryosat-2



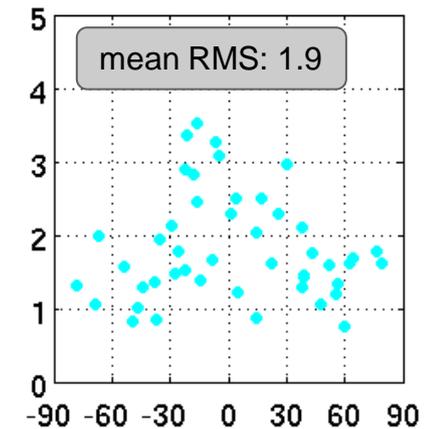
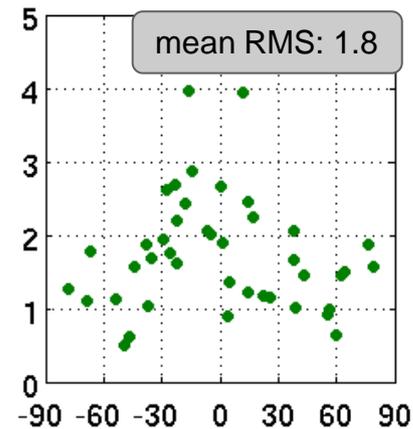
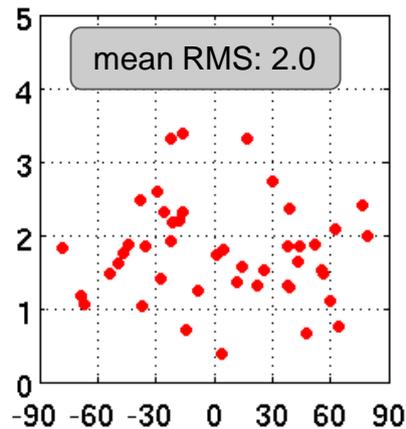
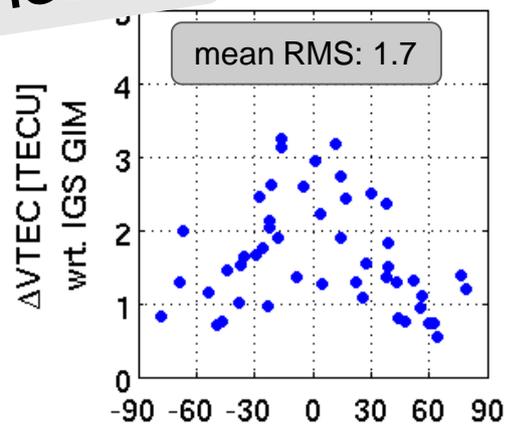
HY-2A



SARAL

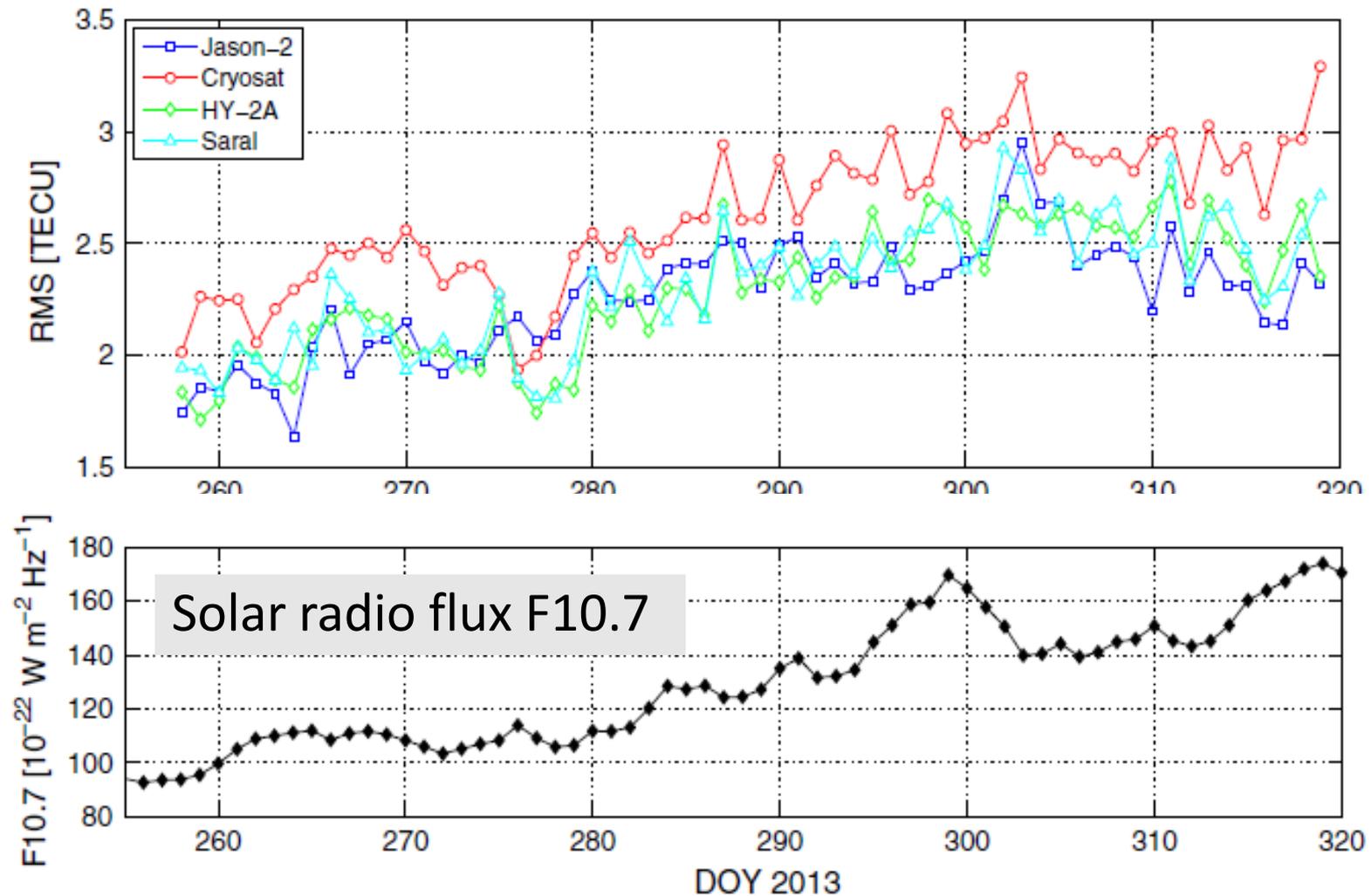


IGS GIM



DORIS VTEC validation

Daily RMS values of DORIS VTEC differences wrt IGS GIM [TECU]
Elevation cutoff angle: 10°



from Dettmering et al, Journal of Geodesy, 2014

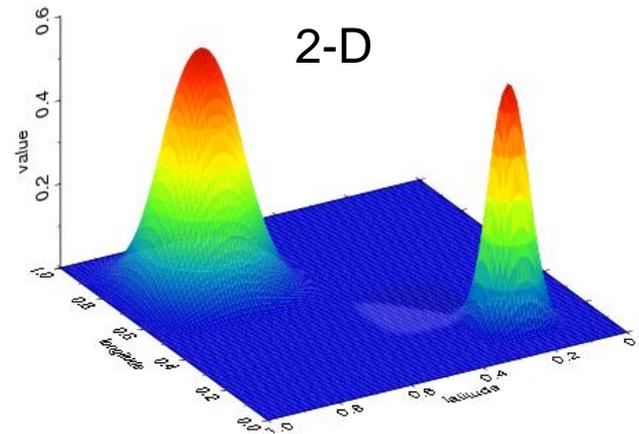
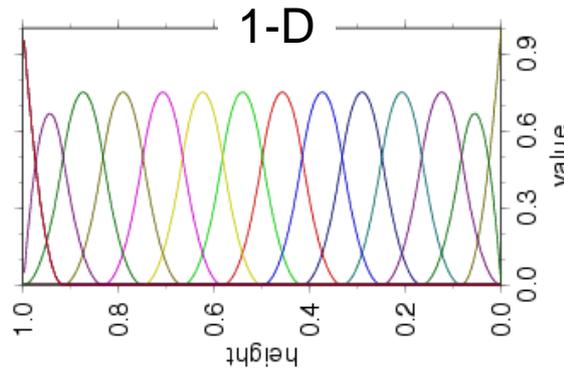
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DGFI's global VTEC model approach

Differences to a given background model (e.g. IRI or IGS GIM) are modeled by a tensor product of one-dimensional B-spline functions.

$$\Delta \text{VTEC}(\phi, \lambda, t) = \sum_{k_1=0}^{K_1-1} \sum_{k_2=0}^{K_2-1} \sum_{k_3=0}^{K_3-1} d_{k_1, k_2, k_3} B_{k_1}^{J_\phi}(\phi) T_{k_2}^{J_\lambda}(\lambda) B_{k_3}^{J_t}(t)$$



Input:

VTEC from different observation techniques (e.g. GNSS, DORIS)
automatic weighting by means of variance component estimation

Output:

unknown series coefficients d_{k_1, k_2, k_3}
(number depends on the B-spline levels J_ϕ , J_λ , and J_t and define the model resolution)

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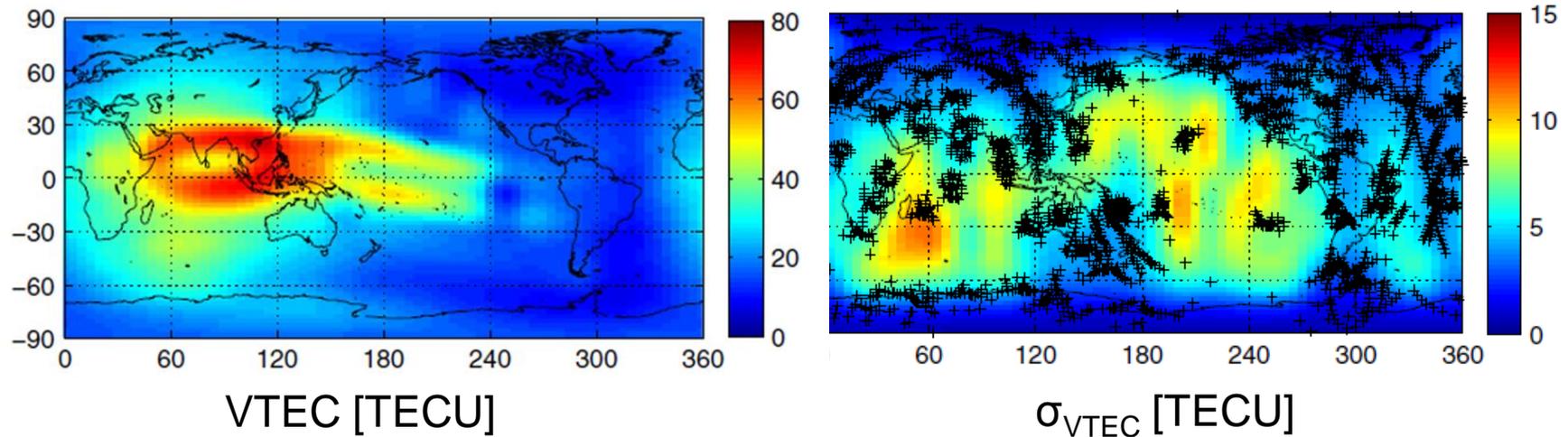
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Global VTEC models – combined solution

Background model: NIC09

Model result for 258/2013; snapshot at 8 UTC

Input: GPS, radio occultations (RO), and DORIS (Jason-2, Cryosat, HY-2A, Saral)



Comparison with IGS GIM and radar altimetry (RA) from Jason-2

	mean σ_{VTEC}	RMS IGS GIM	RMS RA (J2)
GPS	9.2	5.8	6.28
GPS, RO	8.2	5.4	6.16
GPS, RO, DORIS	5.0	4.5	5.44

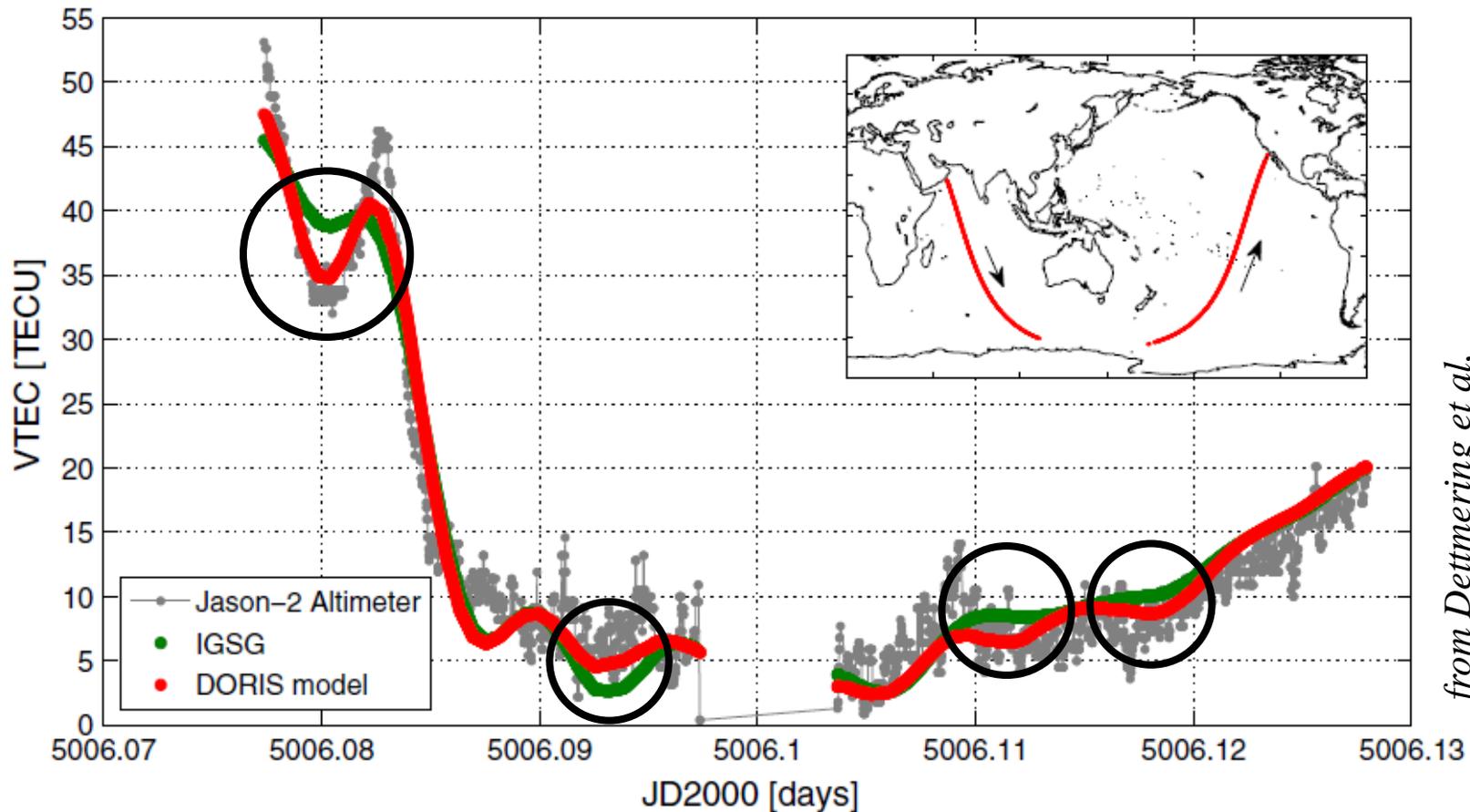
[in TECU]

Global VTEC models – updated IGS GIMs

Background model: IGS GIM

- ⇒ better performance in areas without adequate input data distribution
- ⇒ only DORIS VTEC as input observations

Example for two Jason-2 altimeter passes (258/2013, approx. 90 minutes)

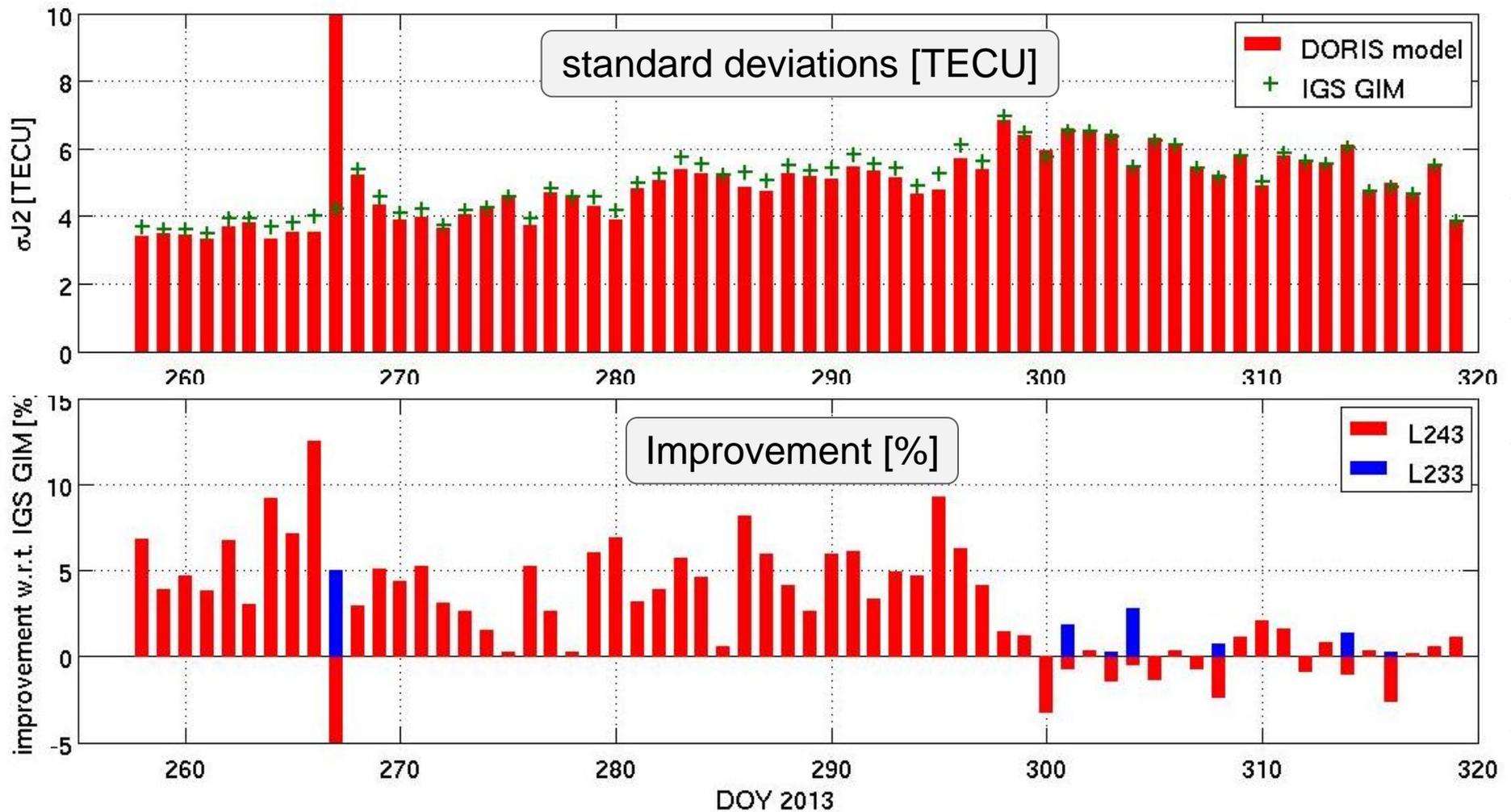


from Dettmering et al,
Journal of Geodesy, 2014

Global VTEC models – updated IGS GIMs

IDS Workshop 2014, 27/28.10.2014

Comparison with Jason-2 RA VTEC



from Detmering et al, Journal of Geodesy, 2014

- ⇒ Significant improvements for most of the days under investigation
- ⇒ Selected days with problems due to inadequate model resolution
- ⇒ DORIS model performance worse for last part of the time series (still under investigation)

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Conclusion

- ✓ DORIS VTEC observations show good consistency with external global models: 1-2 TECU RMS, depending on elevation cutoff and solar conditions
- ✓ Continuous computation of high-resolution DORIS-only global VTEC models impossible due to orbit configuration of current DORIS missions
- ✓ DORIS VTEC values can be of high value for ionospheric modelling when combined with other space-geodetic input data (e.g. GNSS)
- ✓ Including DORIS into GNSS-derived VTEC models (IGS GIM) can improve the consistency with radar altimetry measurements by more than 10% for single days.

Outlook

- ? How will the utilization of an adapted model approach (i.e. local or regional) influence the model accuracy?
- ? Might DORIS measurements be used for operational correction of single-frequency altimeter systems?
- ? What can DORIS measurements contribute to 4-D ionosphere modelling?

Questions ?

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