Atmospheric Loading: Issues for ITRF2013 reprocessing campaign

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outline

- tidal s1 and s2

- non-tidal

    - how to apply

    - existing products

    - observation level versus daily average correction

        - why we should apply at the observation level; what can be gained

        - why we should not apply at the observation level

        - GGFC call
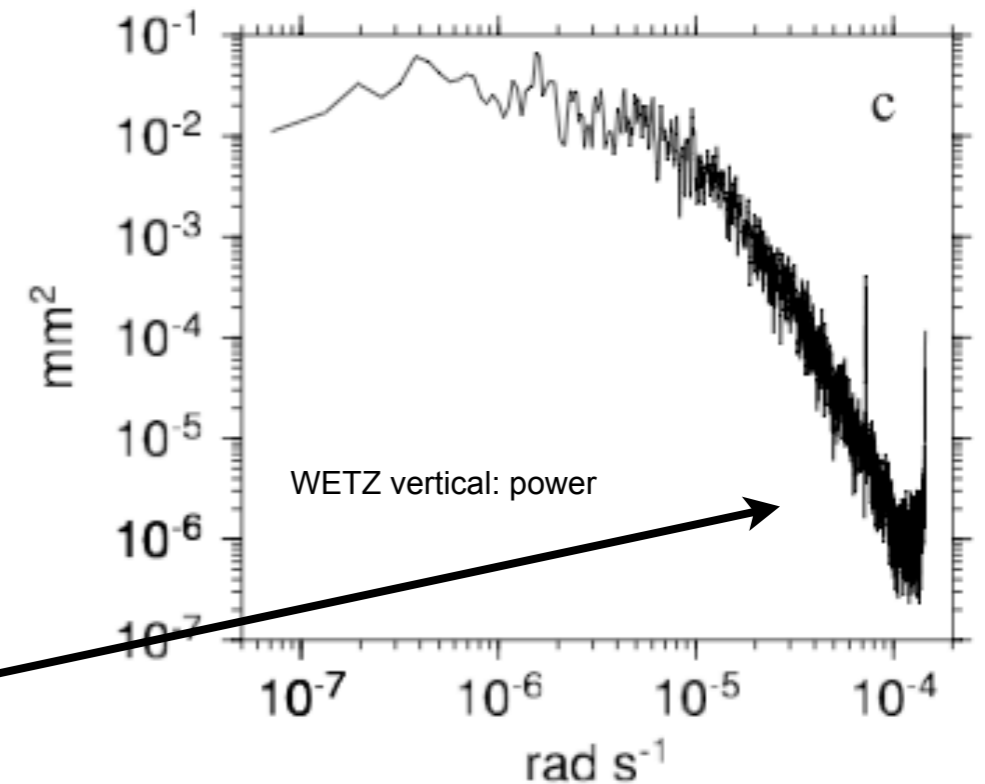
Atmospheric Loading Corrections

- Two components: Tidal S1 and S2 and non-tidal

  - Tidal S1 and S2 (24 and 12 hourly)

  - For the 6 hourly data sets, the tidal part of the GCM's have been shown to be in error (van den Dool et al, 1997; Ponte and Ray, 2003)

  - Models exsits

    - Using a comparison of ground truth with ECMWF, (Ray and Ponte, Annales Geophysicae, 2003)

    - Current IERS model

  - Can be derived from higher temporal resolution data sets

    - Bode and Biancale (2006), the first to use higher temporal resolution data to get around the problem

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Tidal Atmospheric Loading Corrections

- Tidal S1 and S2 (24 and 12 hourly)

    - Corrections for these tides should be applied as a Class 1 effect as set forth in the IERS conventions

        - Do they reduce the RMS?

        - Empirical evidence

            - SLR slight improvement (presentation by J. Ries at the IERS Conventions workshop Paris)

            - GPS little to no evidence of an improvement (Tregoning and Watson, 2009 JGR)

            - VLBI no evidence (Boehm personal communication)

Non-tidal Atmospheric Loading Corrections

- non-tidal component: how to apply

  - If using GCM's to estimate ATML loading, Ray and Ponte (2003) recommend removing tides in existing surface pressure models and using a more precise tidal model

  - How are the tides removed in practice?

    - Petrov and Boy (2004) fit sinusoids at the S1 and S2 frequencies; does not remove the full signal

    - Tregoning and van Dam (2005) low pass filter; gets rid of anything periodic below 26 hours

    - Tregoning and Watson (2009) Butterworth filter

    - must confirm in any case that the tides have been sufficiently removed

WETZ vertical: power

Atmospheric loading corrections

- GGFC atmospheric loading corrections (http://geophy.uni.lu/atmospheres)

  - van Dam (GGFC Operational)

    - 6 hourly; NCEP; low pass filtered; station files and grids

  - Boehm (GGFC Provisional) http://ggosatm.hg.tuwien.ac.at/loading.html

    - 3 hourly; ECMWF Forecast; not-filtered; station files and grids

  - GSFC (GGFC Provisional)

    - Petrov and Boy product

    - 6 hourly; NCEP; polynomial fit to remove the tides; station files and grids

  - J.-P. Boy (GGFC Provisional)

    - http://loading.u-strasbg.fr/ITRF/

    - 3 hourly; ECMWF Forecast; not-filtered; station files

      - inverted barometer and MOG2D dynamic ocean response to pressure and winds

  - all in CF and CM reference frames

ATML Non-tidal component: Observation-level versus a posteriori mean?

- Currently this is a BIG discussion in the operational geodetic community...

- GGFC call for products to try to evaluate options...(to be discussed later)

ATML Non-tidal component: Observation-level versus a posteriori mean?

- **Why we should apply at the obs level...**

    1. Long observing sessions in SLR and DORIS; Weekly SINEX files for the IGS
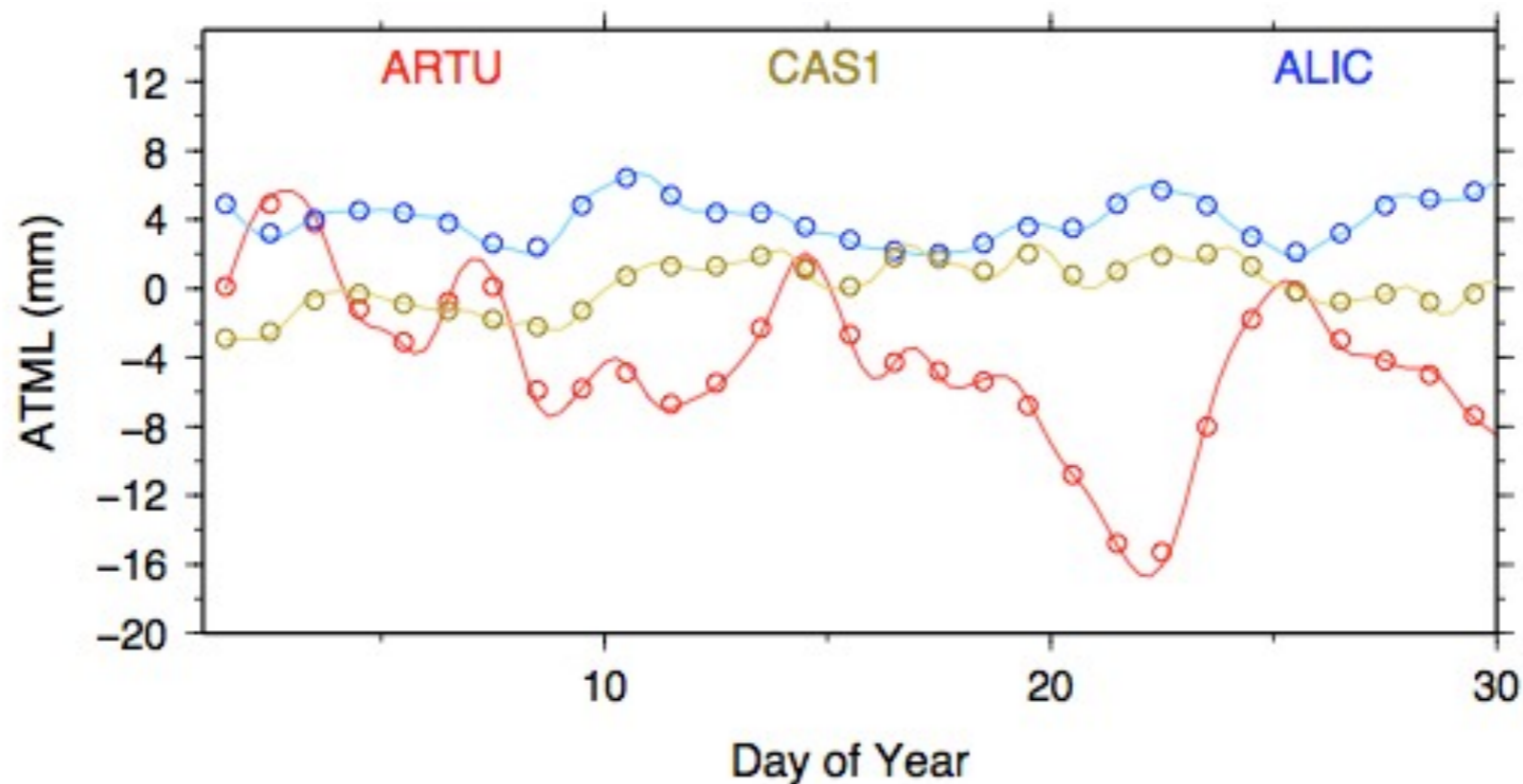
- Weekly SINEX files IGS => Recommendation to go to daily files so this is no longer a real issue

Have any effects been observed in positions?

- Effects on positions

    - Tregoning and Watson (JGR, 2009); daily GPS => no improvement

    - Dach et al. (J. Geod., 2011); weekly GNSS; improvement

    - Boehm VLBI; no improvement

    - Pavlis SLR; EGU 2012; no improvement

    - Tregoning et al. (J. Geod. Submitted)

        - Conclusions

            - Obs level and Daily corrections agree at the 1 mm level 96% of the time

            - agree at the 0.4 mm level 50% of the time

ATML Non-tidal component: Observation-level versus a posteriori mean?

- **Why we should apply at the obs level...**

  2. the correlation between ATML and atmospheric delay estimates

     - changes in station positions during the day due to atmospheric loading will map directly into the atmospheric delay estimates that will be in error if the sub-daily loading is not accounted for
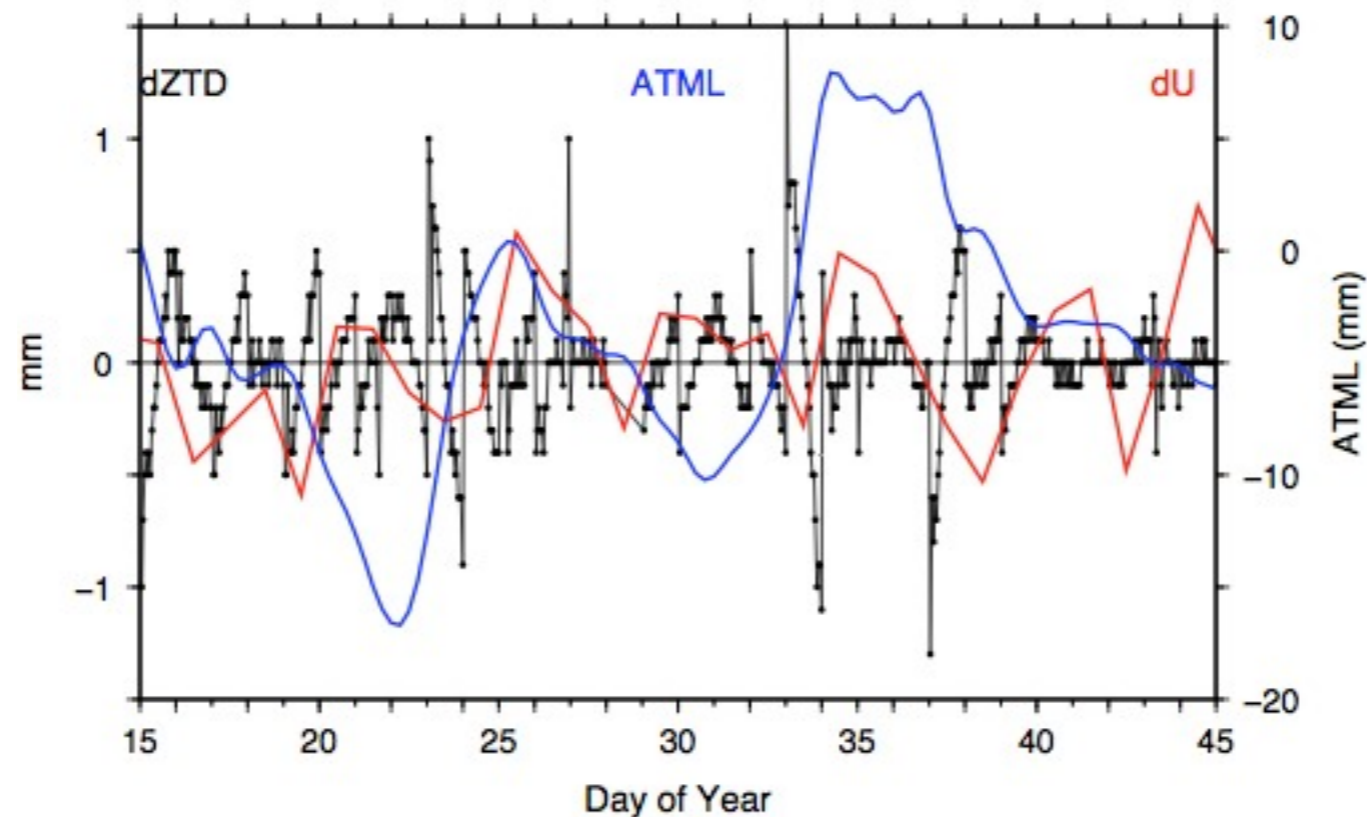
     - differences in dZTD are typically less than 0.5 mm

ATML Non-tidal component: Observation-level versus a posteriori mean?

- Why we should apply at the obs level...

    3. VLBI: neglected loading corrections are absorbed the NNR/ NNT conditions

    - BUT circumventing this problem does not necessitate the corrections being applied at the observation level; daily corrections could be applied at the TRF stacking level to avoid problems of sparse VLBI networks (Ray 2007; Collilieux personal communication)

ATML Non-tidal component: Observation-level versus a posteriori mean

- Why we should **not** apply at the obs level...

  1. We would be removing a non-tidal correction of the station motion at the observation level

     - strongly recommended against in the IERS Conventions

     - signal that is removed cannot be replaced exactly into the daily products

     - which model should we use?

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Atmospheric Loading Corrections

- Why we should **not** apply at the obs level...

RMS [Up(NCEP) - Up(ECMWF)]

2. Model deficiencies

- data sets themselves are not perfect

- offsets when models are changed

  - not in the reanalysis but for real time processing people will use the operational or forecast data sets

- the ocean response: IB or some frequency dependent IB
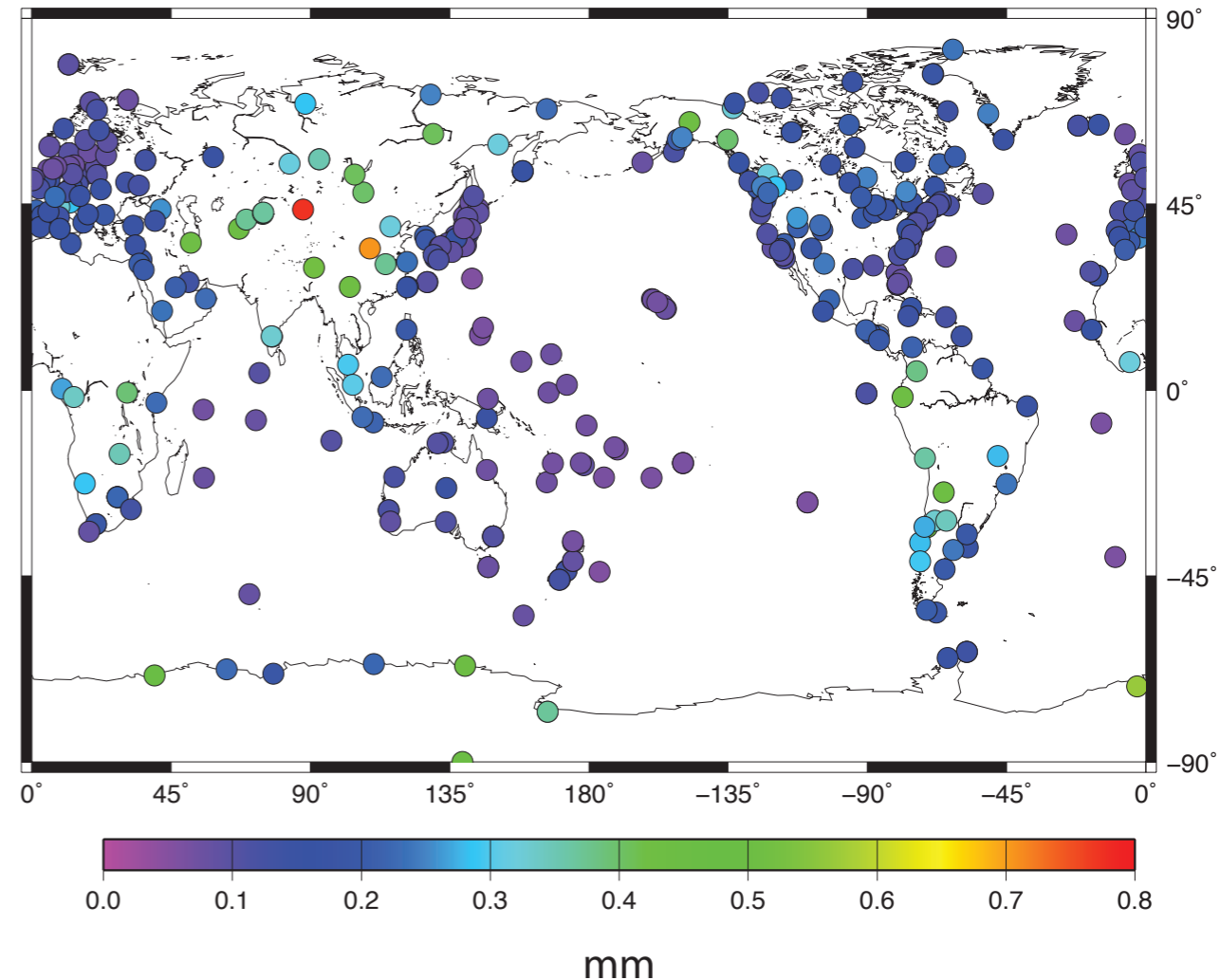
How often to large subdaily station displacements occur?

- **Why we should not apply at the obs level...**

3. The frequency of significant subdaily changes does not justify obs. level corrections

- Maximum of 12 days when the height change at a station is between 10 and 15 mm

- to get a significant displacement, the pressure change has to be large or the extent of a moderate load has to be large

- The problem will be an issue for network processing if the displacement signal is coherent over large distances

number of days with 24 hour height changes

10 mm < n < 15 mm
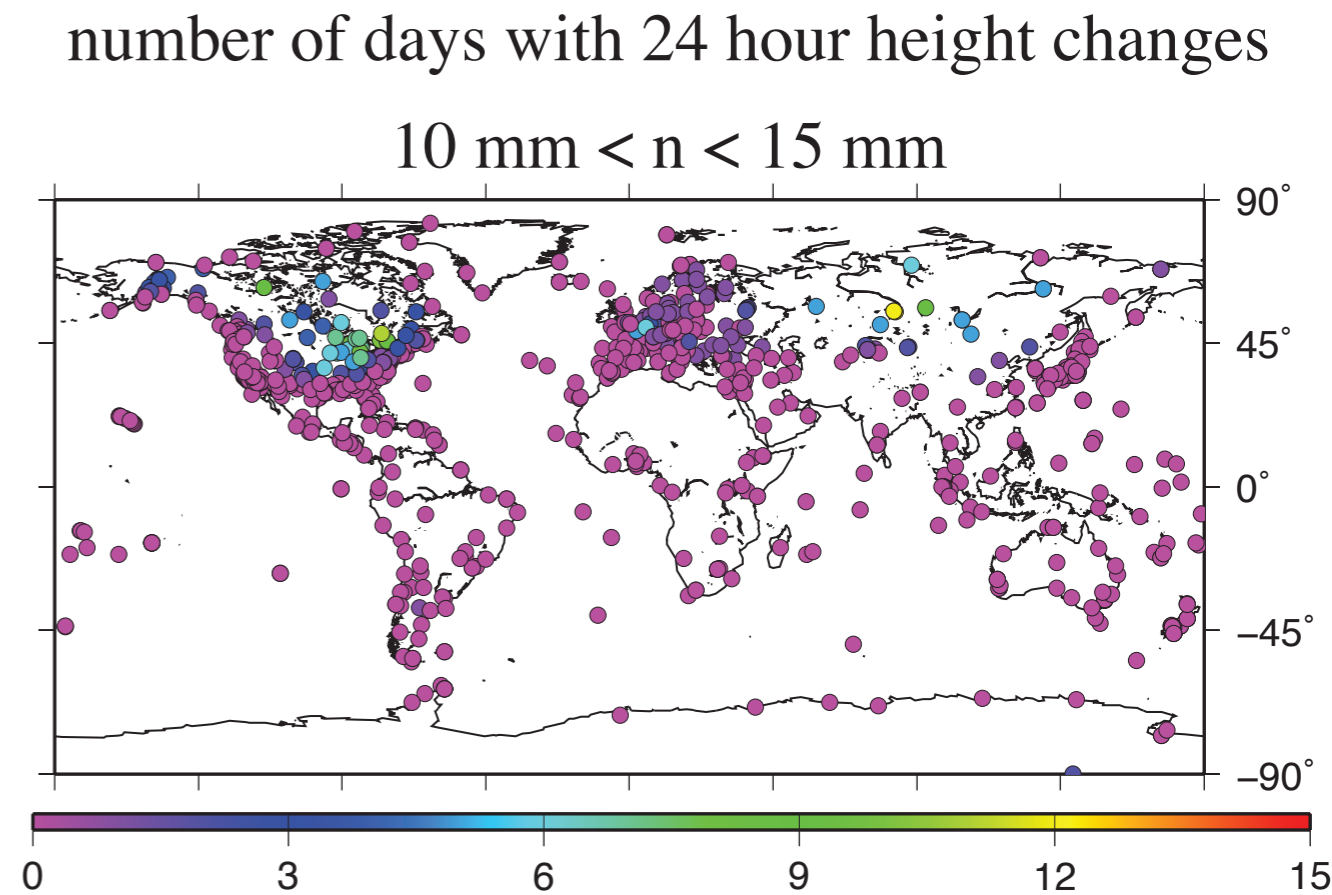
ATML Non-tidal component: Observation-level versus a posteriori mean

- another way to look at the issue of frequency
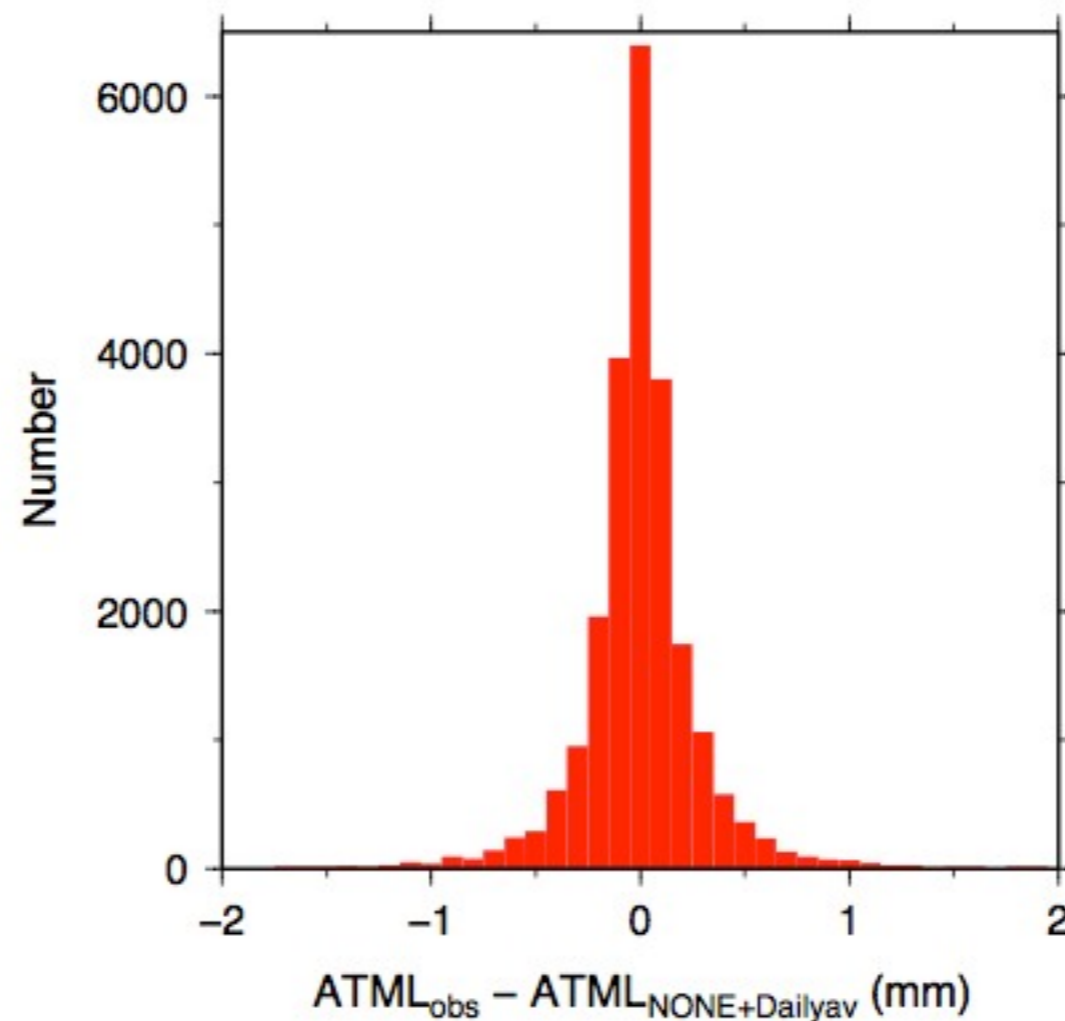
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Atmospheric Loading Corrections

- Open Call by GGFC and ITRF: Come to a consensus as a community for how to handle ATML in the data processing without affecting the ITRF

- http://geophy.uni.lu/ggfc-nonoperational/uwa-call-data.html

  - requesting 3 contributions:

    - sinex files with ATML removed at the obs level

    - sinex files with ATML removed at the obs level and daily average correction correction added back.

    - sinex files no ATML removed

  - Demonstrate that the ITRF is or is not affected by ATML applied at the obs level

    - Test adding back in a daily mean to data processed with ATML at the observation level. Do you get the same positions back?

differences obs level and aposteriori
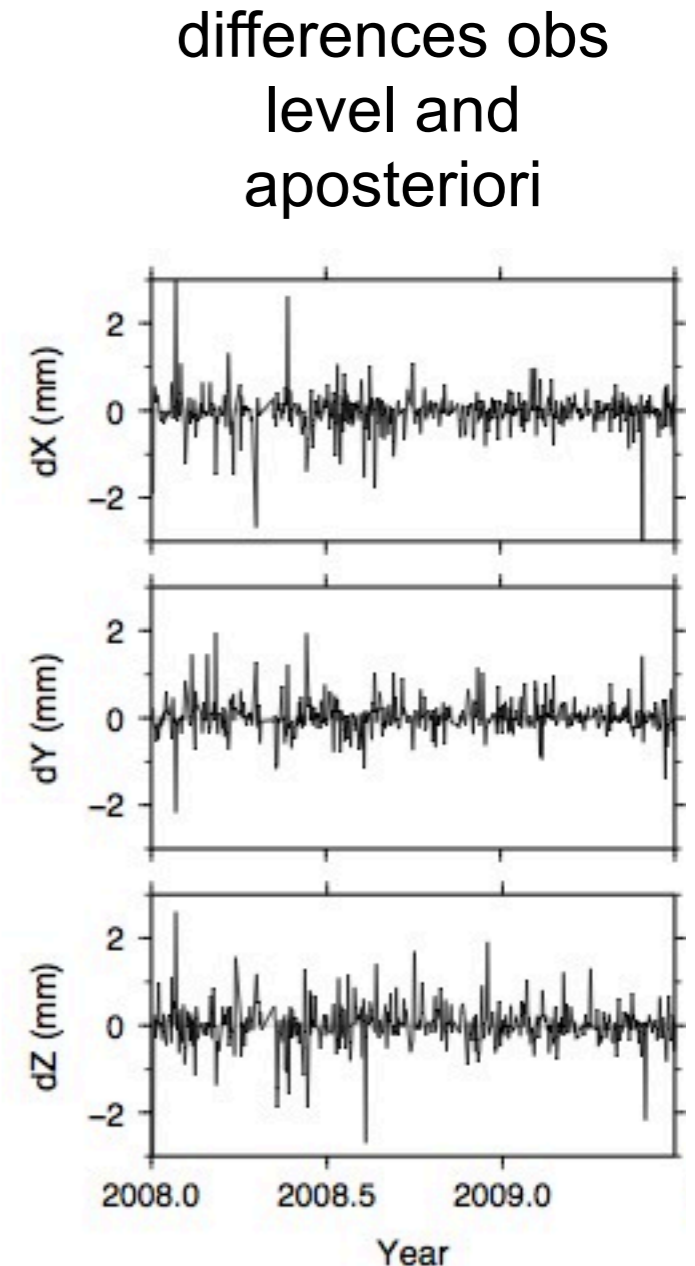
Atmospheric Loading Corrections

- GGFC: Additional Tasks

  - Compare the ATML models available in terms of latency, resolution, precision (GGFC product centers)

  - Tidal models: is there anything better than the current IERS Convention of Ray and Ponte