GPT2/GMF2: An improved empirical model for troposphere delays

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Troposphere delay modeling

\[ \Delta L(e) = \Delta L_h^z \cdot mf_h(e) + \Delta L_w^z \cdot mf_w(e) \]

- if available
  - pressure values at the site (or numerical weather models)
  - ray-traced delays or Vienna Mapping Functions
    coefficients \( a_h \) and \( a_w \)
- otherwise empirical models
  - e.g., Global Pressure and Temperature model (GPT)
  - e.g., Global Mapping Functions (GMF)
## Motivation

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<th>GPT/GMF</th>
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<td>3 years (1999-2002) monthly mean profiles from ERA40 (23 pressure levels)</td>
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## Motivation

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<td>3 years (1999-2002) monthly mean profiles from ERA40 (23 pressure levels)</td>
<td>10 years (2001-2010) monthly mean profiles from ERA-Interim (37 levels)</td>
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<td>Spherical harmonics to degree and order 9 at mean sea level</td>
<td>5 degree grid at mean ETOPO5 heights</td>
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<tr>
<td>Mean and annual terms</td>
<td>Mean, annual, and semiannual terms</td>
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<td>Phase fixed to January 28</td>
<td>Phase estimated</td>
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<td>Pressure ((p)), temperature ((T)), (a_h), (a_w)</td>
<td>(p), (T), lapse rate ((dT)), water vapour pressure ((e)), (a_h), (a_w)</td>
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GPT2 - Pressure

- Annual amplitude and phase of the pressure
• Annual amplitude and phase of the temperature
GPT2 – Temperature lapse rate

- GPT: -6.5 °C/km
- GPT2: Mean, annual and semi-annual
GPT2 – Specific humidity

- Mean and semi-annual amplitude of specific humidity
Algorithm for GPT2

- Selection of four grid points around the site
- Determine parameters at those grid points
- Reduction to the site height ($dT, Tv$)
- Bilinear interpolation
Algorithm for GPT2

- Hydrostatic zenith delay at Kokee at 1177 m height
- Grid points at sea level
Resolution of grid – 1° vs 5°

- Mean pressure and hydrostatic mapping function
- Rule of thumb to express difference in height

99% of grid points < 1 mm
GPT2 (5°) vs GPT

- Pressure: bias and std. dev. (hPa)
Comparison with in-situ data

GPT

GPT2
GPT2 (5°) vs GPT

- Pressure: bias and std. dev. (mm)
GPT2 (5°) vs GMF

- Hydrostatic mf: bias and std. dev. (mm)
GPT2 (5°) vs GMF

- Wet mf: bias and std. dev. (mm)
GPT2 (5°) vs GPT

- Temperature: bias and std. dev.
VLBI analysis

• Global solution with VieVS (1984 – 2012.5)
• Correction of atmosphere pressure loading
• Comparison of station heights from three solutions
  – VMF1 with pressure values at the site
  – GPT/GMF
  – GPT2
VLBI analysis

- Mean station height differences w.r.t. VMF1
VLBI analysis

• Mean height differences w.r.t. VMF1
Conclusions

- New empirical (blind) model for troposphere delay modeling: GPT2
- GPT2 replaces GPT/GMF
- Higher resolution in space and time
- Additional parameters: $dT$, $e$, $a_h$, $a_w$
- Allow modeling of zenith wet delays
- Coefficients $a_h$ and $a_w$ to be used with vmf1_ht.f
- Available at: http://ggosatm.hg.tuwien.ac.at/DELAY/SOURCE
THANKS FOR YOUR ATTENTION