

Ray-traced troposphere slant delays from numerical weather models as corrections on the observation level – status and outlook

Hobiger T., Ichikawa R., Koyama Y. and T. Kondo

National Institute of Information and Communications Technology,
Japan

Numerical weather models

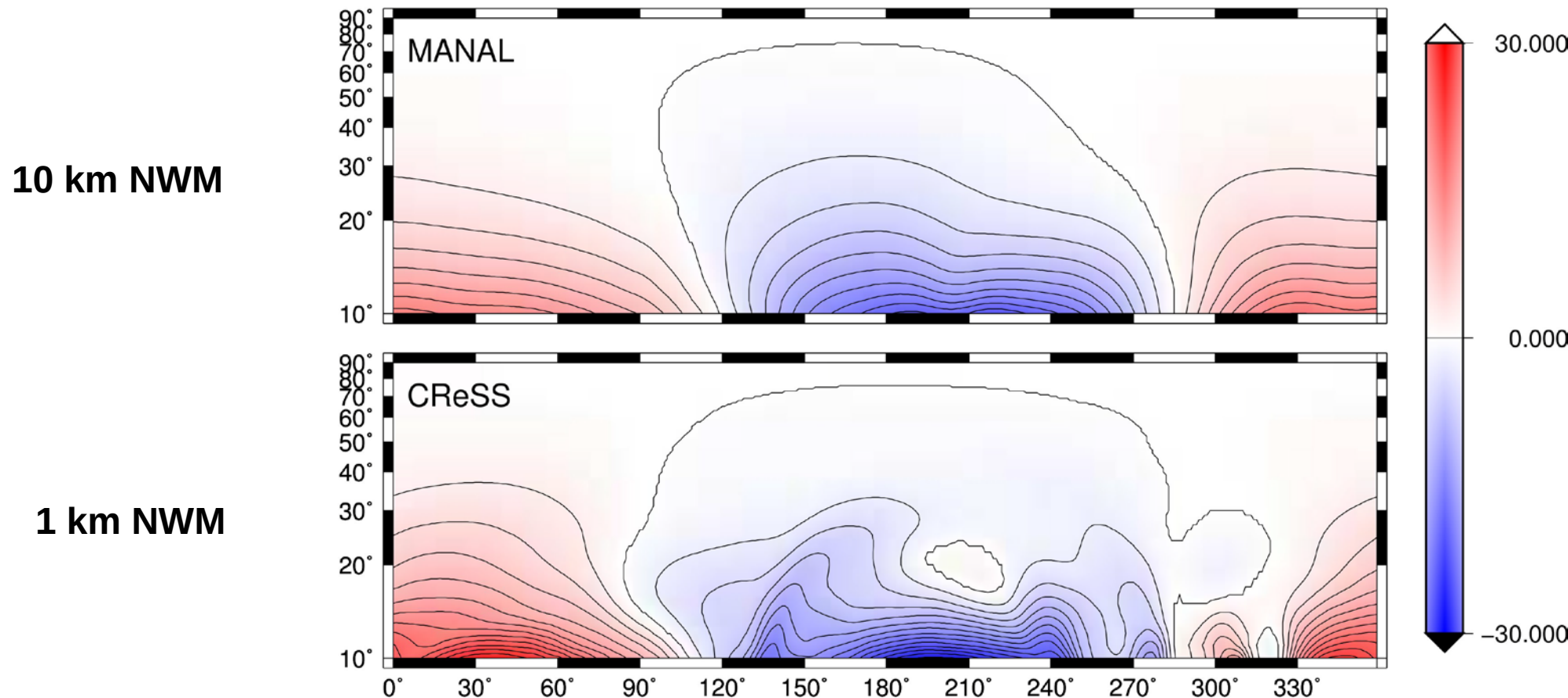
- Are being used for
 - Computation of mapping function coefficients
 - Modeling of ground pressure / temperature
 - Atmosphere loading
 - Atmospheric excitation
- Can be used for direct delay correction
 - SLR: e.g. Hulley and Pavlis, JGR 2007
 - GPS: e.g. Hobiger et. al, EPS 2008
 - VLBI: e.g. Boehm et al., JoG 2010 (under review)
 - InSAR: e.g. Hobiger et al., JoG 2010 (under review)

Total troposphere delays from NWMs

- Numerical weather models are accurate by about 99% of total delay
- Estimation of residual zenith total delays (ZTD) by a simple mapping function ($1/\sin(e)$) is still necessary for mm-accurate positioning
- Big advantage: no gradient estimation necessary
- cm accurate solutions can be achieved even without estimating any troposphere contribution

Information content depending on the NWM resolution

Asymmetric troposphere delay at GEONET site 3017 (Tokyo), Sep. 7th, 2007 12h UT

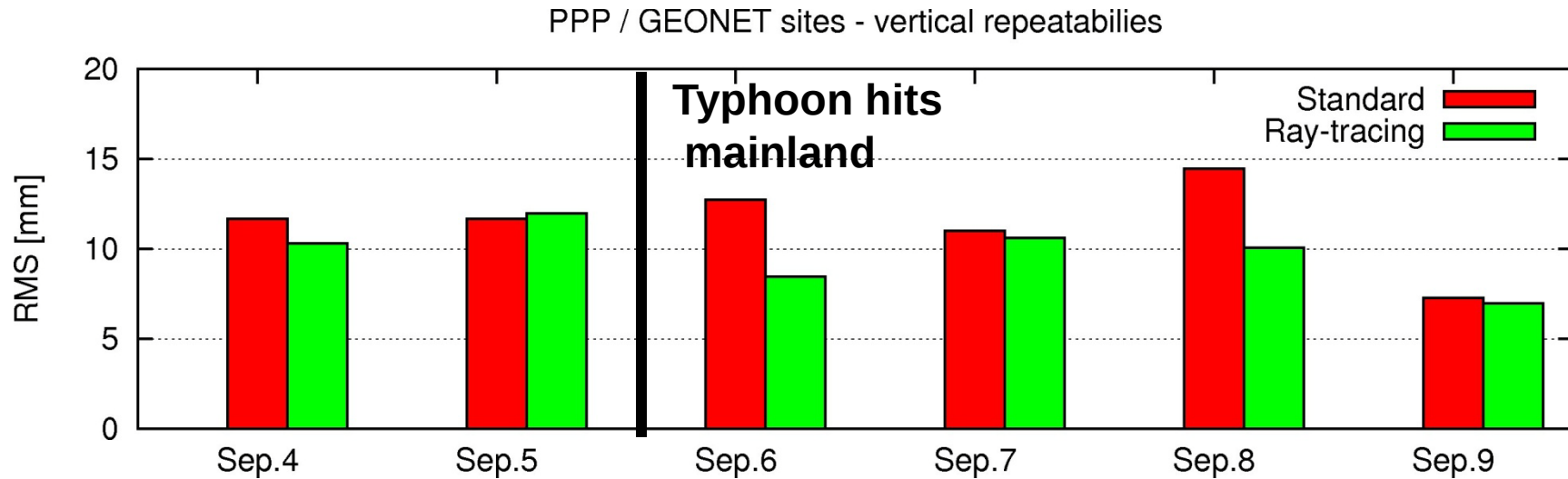


from: Hobiger et al., JASTP, 2010

Impact of troposphere delay corrections

- **SLR:**
 - reduces variance of the residuals by up to 40% [Hulley and Pavlis, JGR, 2007]
- **GPS:**
 - moderate improvements (1-10%) of site position repeatabilities w.r.t. GMF + gradients [Hobiger et al., EPS, 2008]
 - Significant improvement w. fine-mesh model during severe weather conditions (up to 30% improvement of site position repeatabilities) [Hobiger et al., JASTP, 2010]
- **VLBI:**
 - helps to reduce artifacts in UT1 estimates on single baseline sessions [Boehm et al., JoG, 2010]
- **InSAR:**
 - Improves interpretation of the underlying geophysical signals [Hobiger et al., JoG, under review]

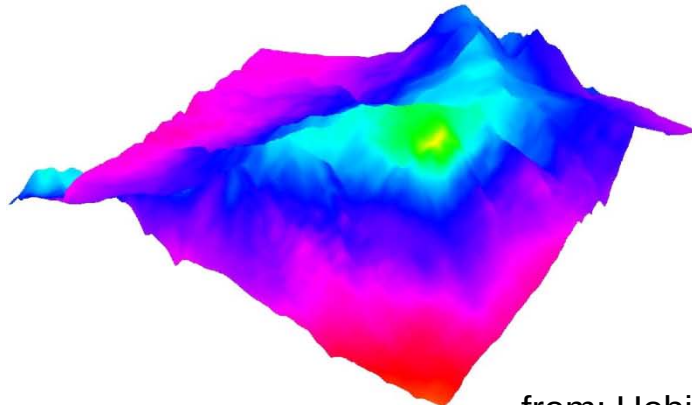
GPS stations around Tokyo during typhoon, Sep.4-9 2008



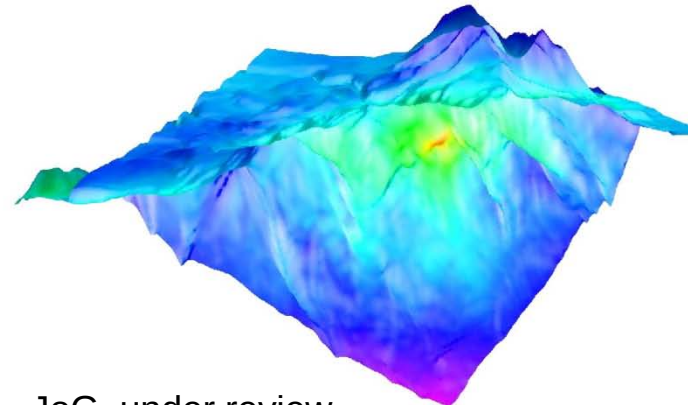
from: Hobiger et al., JASTP, 2010

Deformations based on remote sensing data (InSAR), Tokachi-dake volcano, Japan

No atmosphere correction



With atmosphere correction

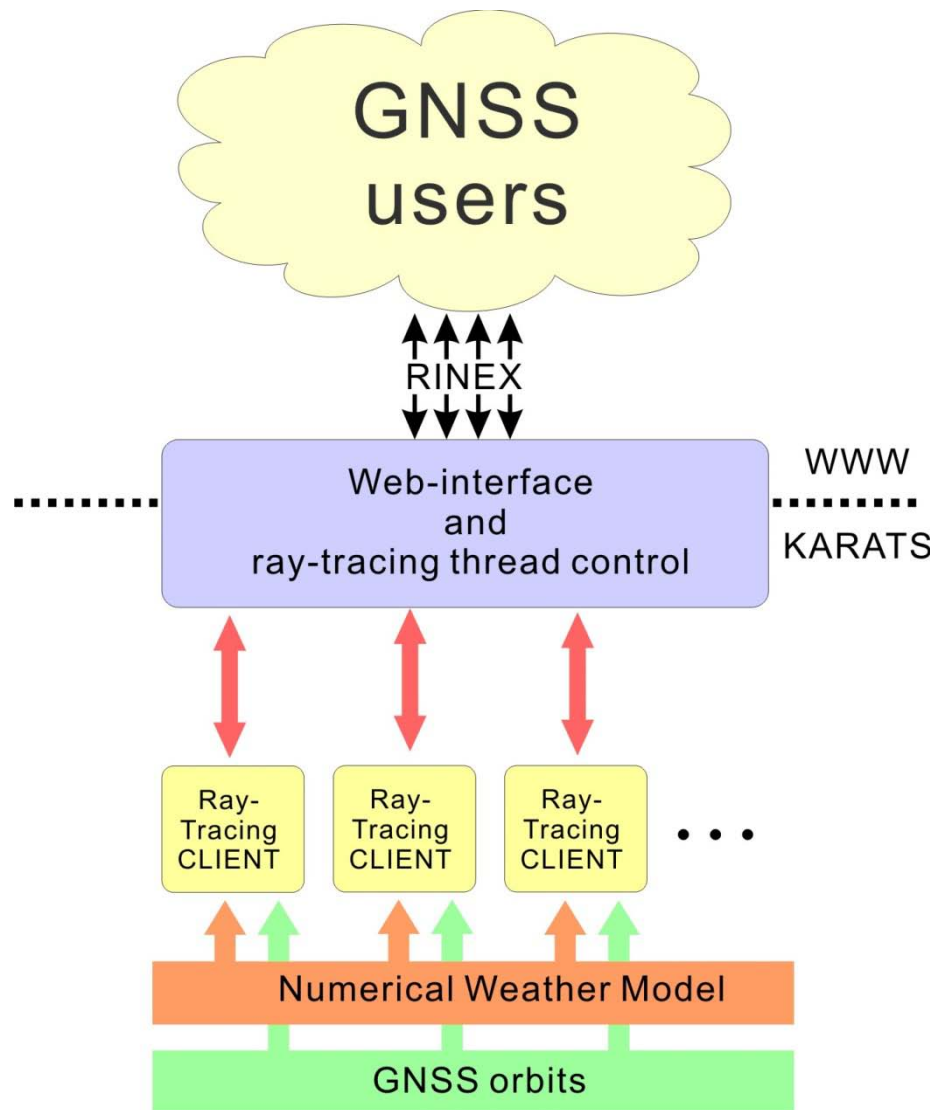
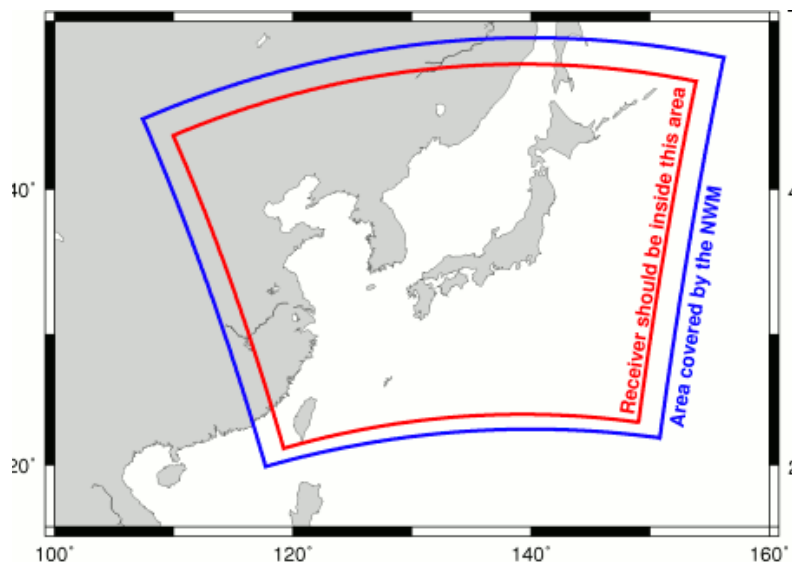


from: Hobiger et al., JoG, under review

How to bring the corrections to the user?

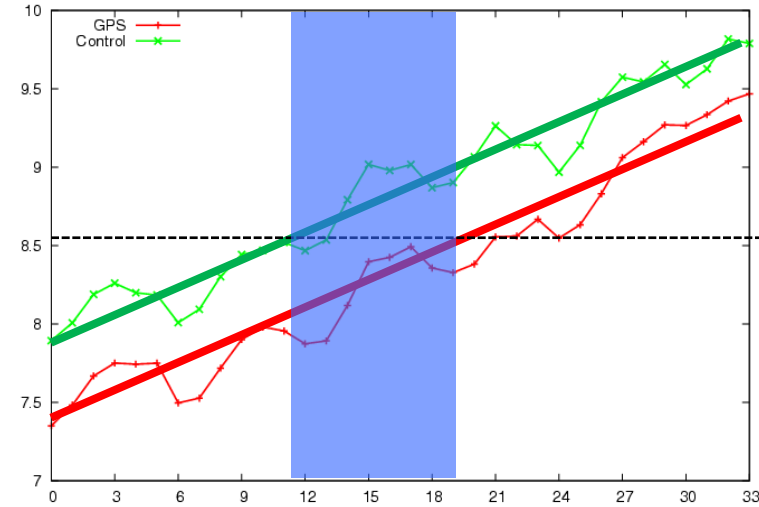


<http://vps.nict.go.jp/karats>



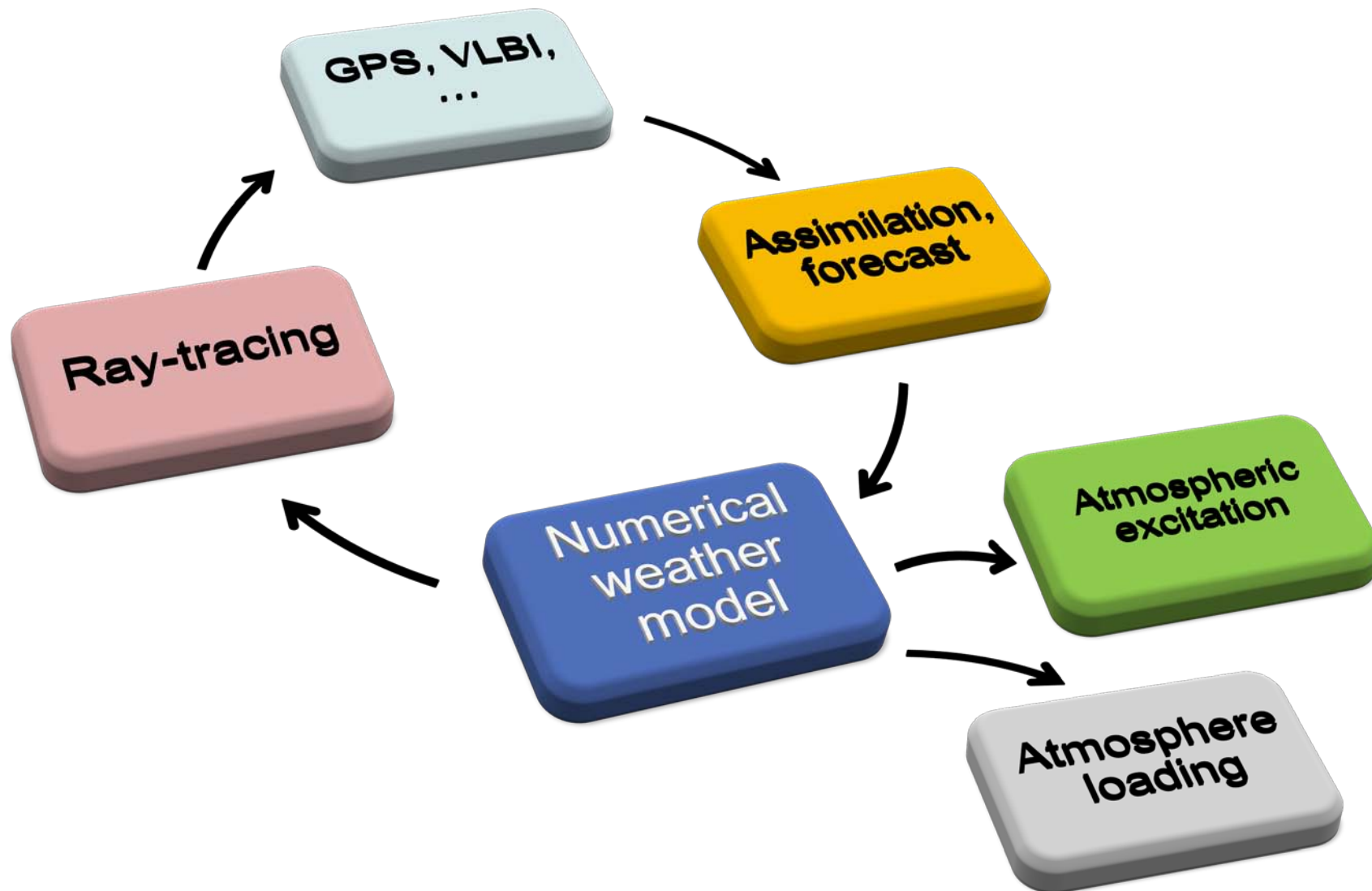
The next steps ...

- Corrections only as good as the numerical weather models
 - Fine-mesh models preferable
 - Accurate modeling of clouds and water vapor structures required
 - Quality of forecast data needs to be improved
- Assimilation improves NWMs
 - JMA assimilates ZTDs from 1200 GPS receivers into their meso-scale model on a routine base since Oct. 27th, 2009



Forecast quality extends
by ~ 6 hours

Interaction: space geodesy $\leftrightarrow$ meteorology



Implications

- Use consistent model domains and/or
- Apply consistent transformations between them (TRF $\leftrightarrow$ NWM)
- Use unambiguous data interchange formats
- Aim at (near) real-time operation
- Not necessary to derive ZTD from space geodesy; estimated residual Δ ZTD can be used as corrector in NWM run

Outlook

- NWM spatial resolutions goes towards 1km scale
 - Finer atmosphere structures covered by the mode
 - Currently only local coverage (a few hundred km)
 - Global coverage bounded by memory requirements / computation time
- Temporal resolution:
 - Basically data available for each time-step (minute scale) with which the model is run
 - Which resolution is required for the computation of troposphere delays?
- Use one model for all techniques and all type of corrections to ensure consistency

Thank you very much
for your attention

Contact: hobiger@nict.go.jp