

# Travelling Ionospheric Disturbances

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**TREASURE**  
TRAINING RESEARCH AND  
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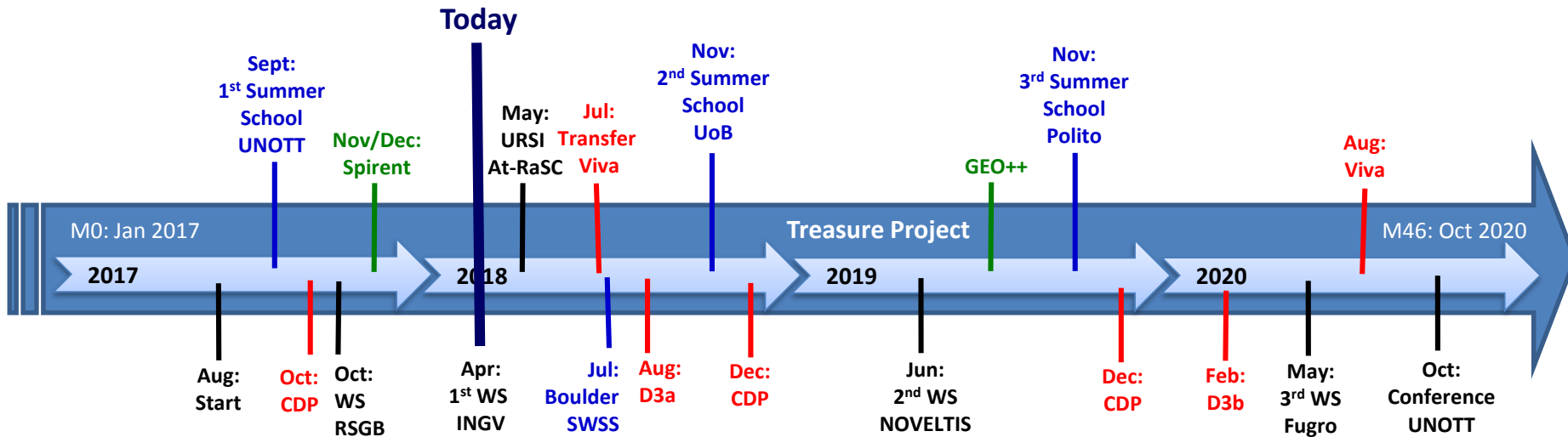


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# Research Plan and Objectives



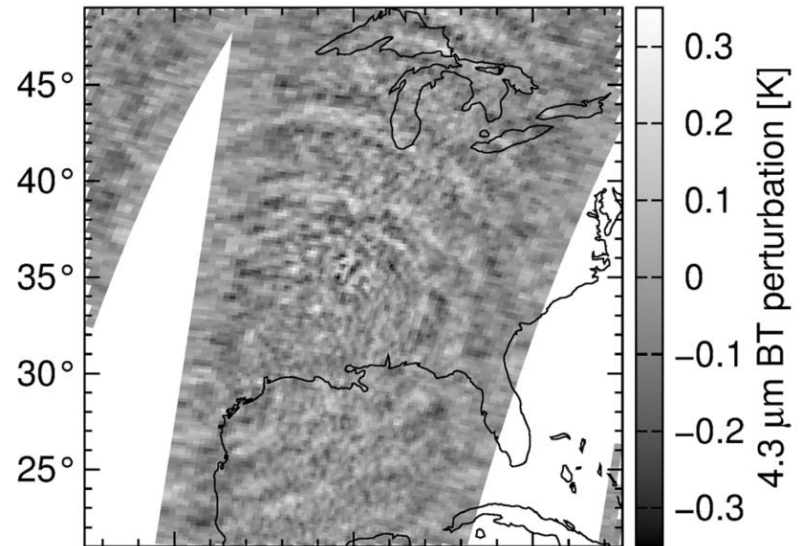
## Travelling Ionospheric Disturbance Modelling and Mitigation

1. Model Travelling Ionospheric Disturbances (TIDs)
2. Identify TIDs in real data
3. Mitigate TID effects on precise positioning

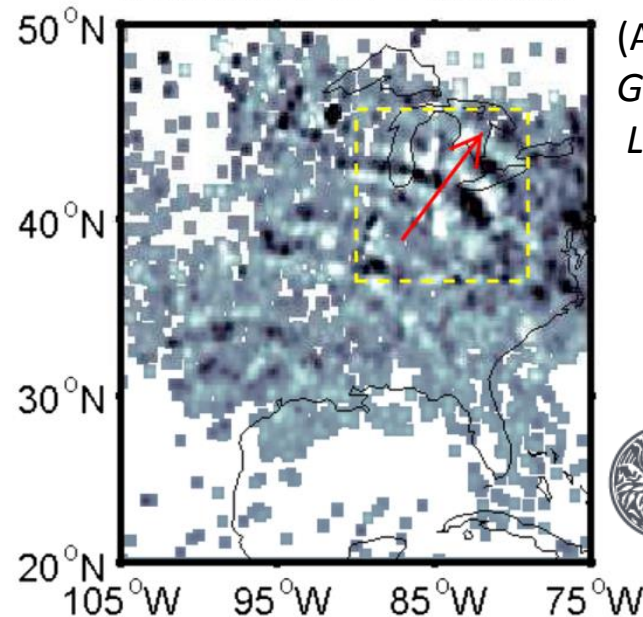
# Travelling Ionospheric Disturbances (TIDs)

- Wave-like modulations in ionospheric parameters
- Closely related to **gravity waves** (GWs) in the neutral atmosphere
- Varying spatial scales, depending on source

AIRS | 04-APR-2014, 07:55 UTC

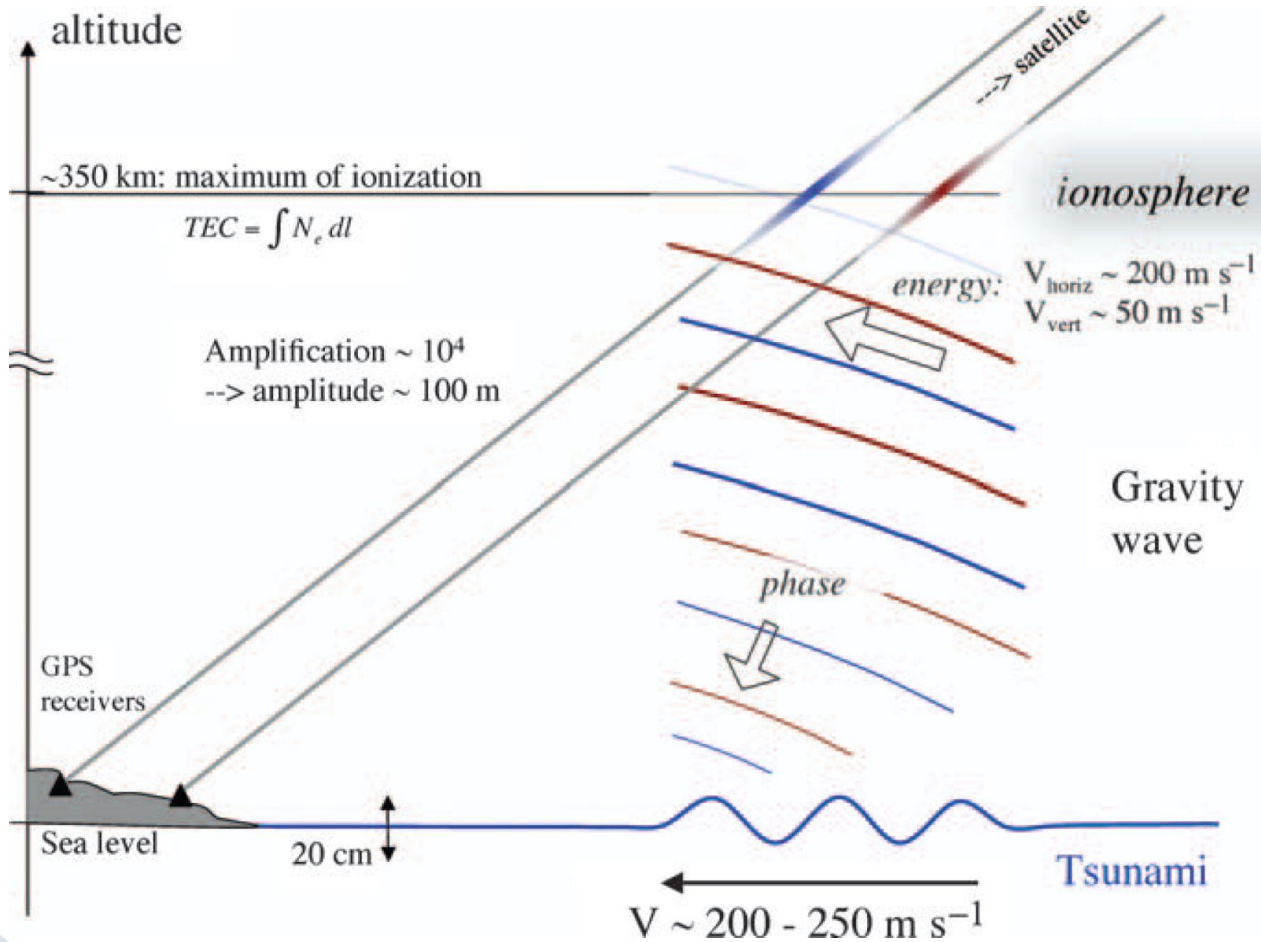


04/04/2014 UT = 09:50:00



(Azeem & al.,  
*Geophysical Res. Letters* 2015)

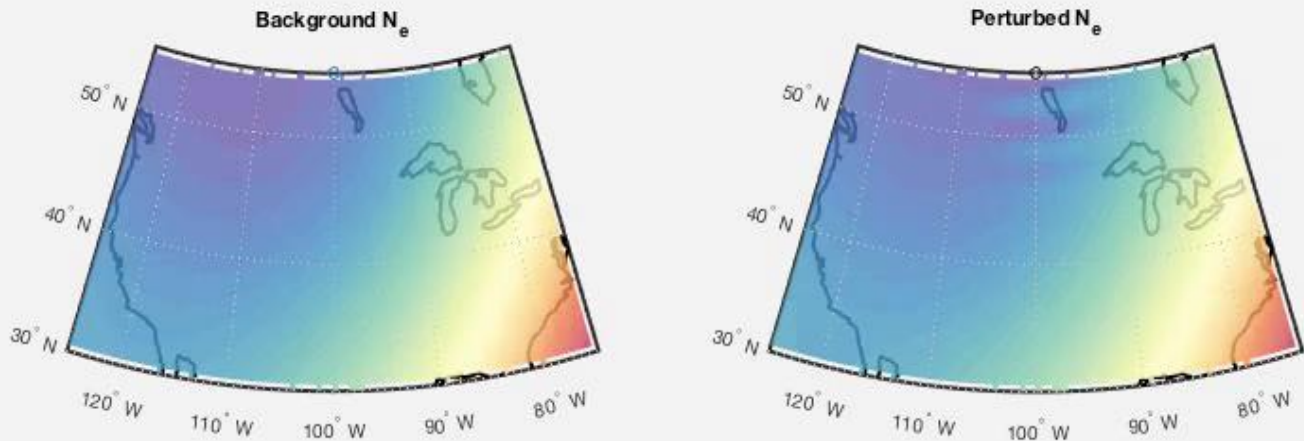
# TID/GW Generation



(Artru et al., *Geophysical Journal International* 2005)

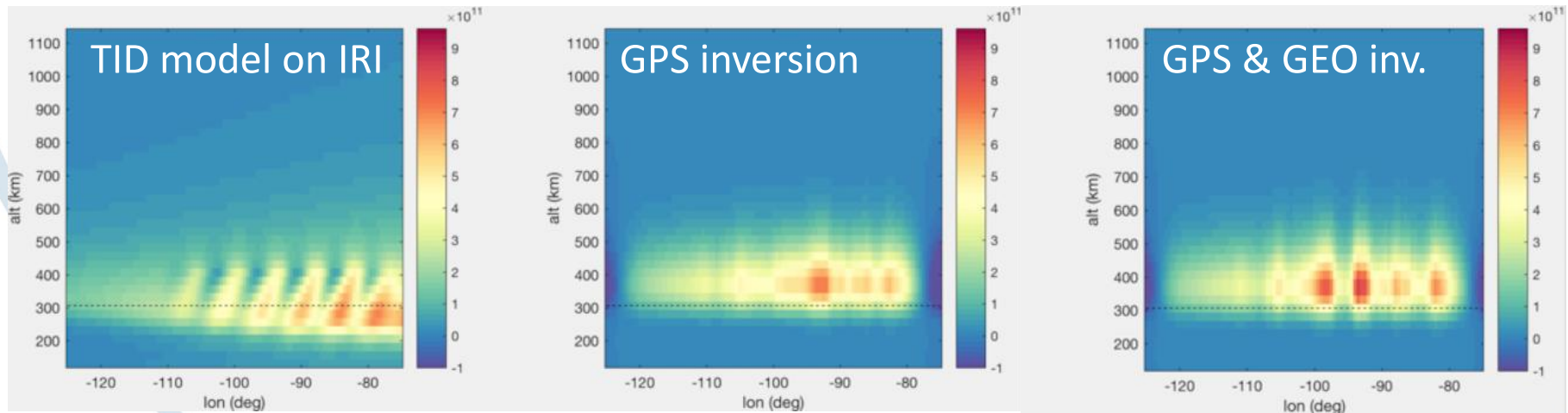
# Modelling TIDs

- Hooke model 
$$\frac{N'_e}{N_{e0}} = \frac{u_b}{\omega} \left[ k_{br} + i \left( \frac{\partial_z N_{e0}}{N_{e0}} + k_{zi} \right) \sin I \right]$$
- Gravity wave parameters  $\mathbf{k}$ ,  $\omega$ ,  $u$
- Relative density modulation on 4D IRI background



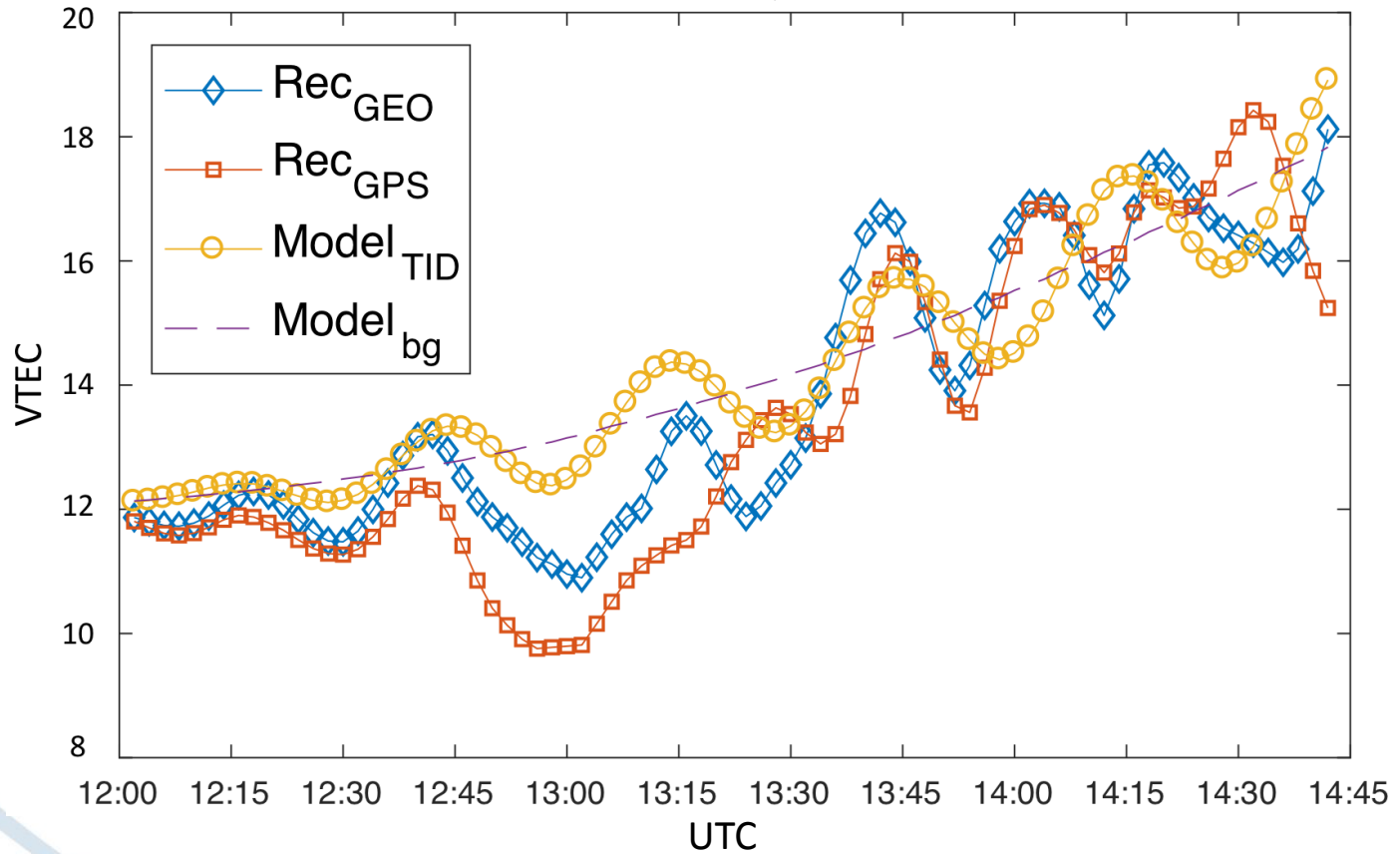
# Testing MIDAS Inversion on TID Model

- Vertical profiles from 3 US ionosondes
- Varying satellite geometry



# Model Inversion TEC

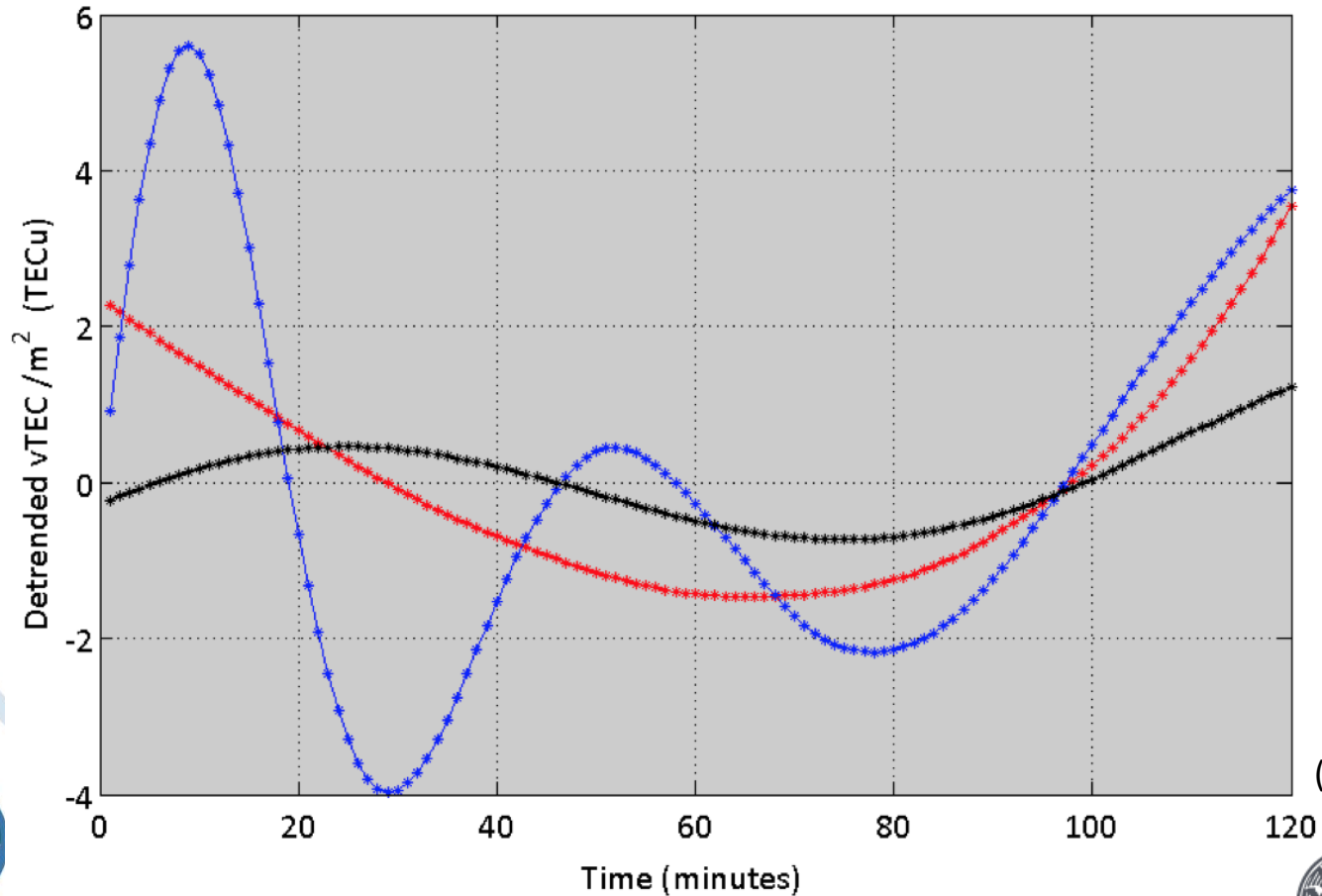
vTEC at lat = 50, lon = -100





# Satellite–TID Relative Movement

Three different GPS satellites and the same wave



(Mitchell 2017)

# Continued Research

- Compare real data inversions and model inversions
- Add GLONASS, Galileo to inversion
- Add DORIS equipped LEO satellite geometry to inversion
- Identify TIDs in reconstructed maps of real GNSS data

# References

W. H. Hooke (1968). Ionospheric irregularities produced by internal atmospheric gravity waves. *Journal of Atm. and Terr. Physics* 30, 795-823.

J. Artru, V. Ducic, H. Kanamori, P. Lognonné & M. Murakami (2005). Ionospheric Detection of Gravity Waves Induced by Tsunamis. *Geophysical Journal International* 160, 840-848.

I. Azeem, J. Yue, L. Hoffmann, S. Miller, W. Straka, G. Crowley (2015). Multisensor profiling of a concentric gravity wave event propagating from the troposphere to the ionosphere. *Geophysical Research Letters* 42, 7874-7880.