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day-to-day ionosphere variability

F-3/C: 30 days 2-hrs data spin-up

F-7/C-2: 2-hrs data spin-up
Daily global electron density - TACC product data assimilation of RO Iono. TECs

Full Kalman filter
Assimilation of RO Iono. TECs

Ensemble Kalman filter DA Assimilation of Ne profile

Physical Model

Data Assimilation Results

The slant TEC track of GPS & F-3/C data UT00 Feb-5-2008
Ionospheric Data Assimilation Model

**Observations**
- Ionosonde/digisonde
- ISR
- GPSTEC
- GPS RO
- IVM
- Airglow/EUV Imager

**Method**
- 3D-Var
- 4D-Var
- KF
- EnKF
- LETKF

**Model**
- FPFIM
- IFM
- IPM
- TIEGCM
- SAMI-3
- GAIA

Global distribution of ground-based GNSS and FORMOSAT-3/COSMIC

26 September 2011 Geomagnetic Storm

![Global distribution of ground-based GNSS and FORMOSAT-3/COSMIC](image)

![26 September 2011 Geomagnetic Storm](image)
Storm time data assimilation (10-min assimilation cycle)

Prior (forecast)

Posterior (nowcast)

[Chen et al., 2016]
Assimilation for 2015 St. Patrick Storm

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- Diff. high lat. forcing
- Heelis & Weimer
- 10-mins cycle

*Chen et al., 2016 shows that if assimilation cycle is 60 mins., the result is similar to NO assimilation.*

- Un-obs. state var. 
  \( T_n, V, U, [O], [O_2] \)
  adjusted based on each of their relationships with TEC
  [Matsuo et al., 2012; Lee et al., 2012; Hsu et al., 2015; Chen et al., 2016]

- Indicating importance of driving force of the background model
Forecast time/error @ various latitudes

\[ \text{RMSD} = \sqrt{\frac{\sum_{i=1}^{n}(x_{\text{obs},i} - x_{\text{model},i})^2}{n}} \]

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DART/TIEGCM-Heelis

DART/TIEGCM-Weimer
Storm-time eastward E-field adjustments

2015 St. Patrick’s Day storm (17 March)

(a) 03/16, 1400UT

(b) 03/17, 1400UT

Ionosonde-derived PRE vertical drifts
Joshi et al., [2016]

- Heelis model as high latitude convection specifications.
- Dusk eastward E-field appears after assimilation of TECs.
- ExB @ dusk of 16/17 March
  Heelis ~ 31 / 78.8 m/s
  Weimer ~ 25 / 129.4 m/s
3–days before the storm, during quiet time (14 March 2015)

Background model underestimated the pre-reversal enhancement (PRE) effect and it is adjusted by the assimilation.
PRE of vertical drift or eastward E-field
Prominent plasma bubbles occurred on 14 March 2015 due to strong PRE
It is time to go for plasma bubble forecast model.
Summary

• FORMOSAT–3/COSMIC promotes ionosphere data assimilation model.

• FORMOSAT–3/COSMIC provides new insights to ionospheric plasma structure in climatology point of view; FORMOSAT–7/COSMIC–2 will be able to provide day-to-day global ionosphere variability. New data product will be available in data center.

• Through assimilation of Ne and TEC, ionosphere E–field can be improved. The E–field in evening (Pre–reversal enhancement) is a key driver for plasma bubble generation.

• With ExB drifts (COSMIC–2, ICON), beacon transmitter & RO–S4 (COSMIC–2), neutral temp. & winds (ICON), neutral compositions (GOLD, ICON), we could move forward to the assimilation model of smaller scale ionosphere structure (irregularities).