

# TEC variability over Europe during the 2019 SSW

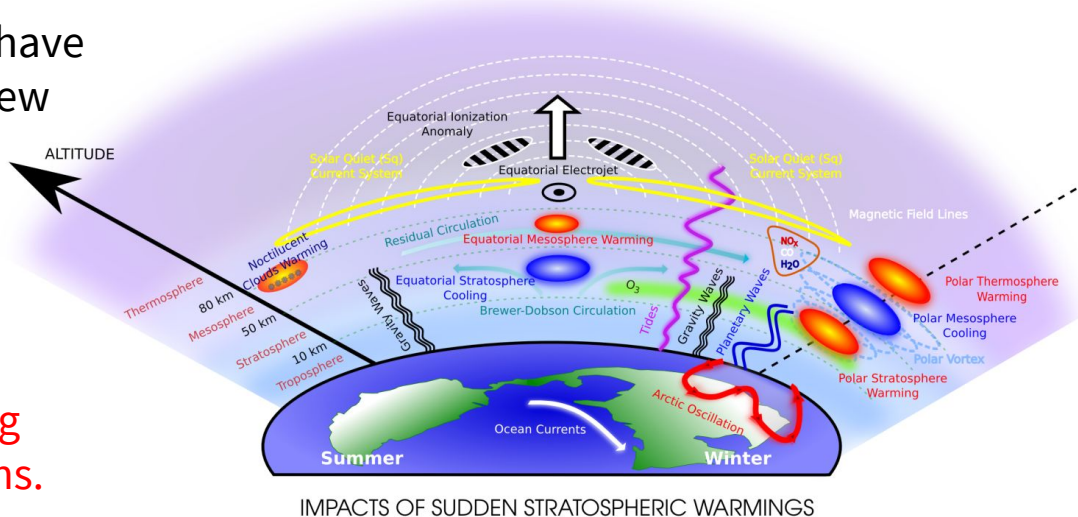
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European Geophysical Union, ST3.2, 08 May 2020

# Background and Motivation

- SSWs are extreme meteorological events that affect the atmosphere globally.
- The ionospheric impacts of SSWs have been well reported over the past few years and are known to be caused due to atmospheric tidal variability associated with SSWs.
- Understanding the TEC variability at mid-latitudes during SSWs using WACCM-X and TIE-GCM simulations.



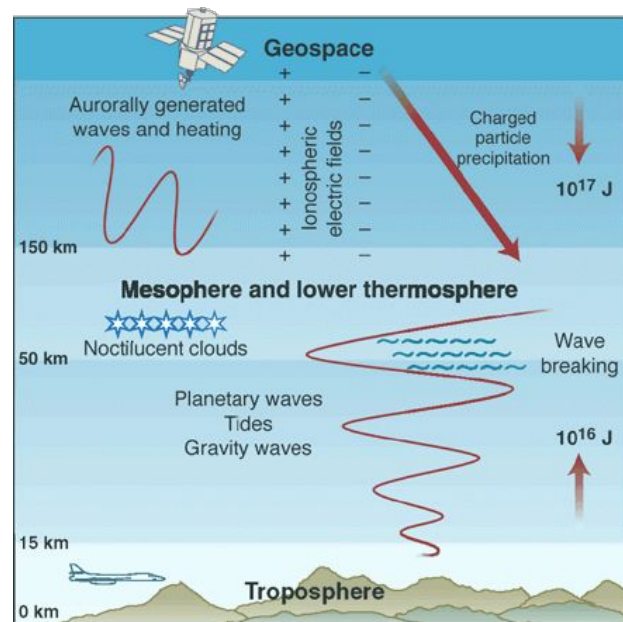
# WACCM-X and TIE-GCM

TIE-GCM is a first-principles, 3D, model of the coupled TI system and spans from 97-750 km.  
<https://www.hao.ucar.edu/modeling/tgcm/tie.php>

It includes a self-consistent solution of the middle and low-latitude dynamo field

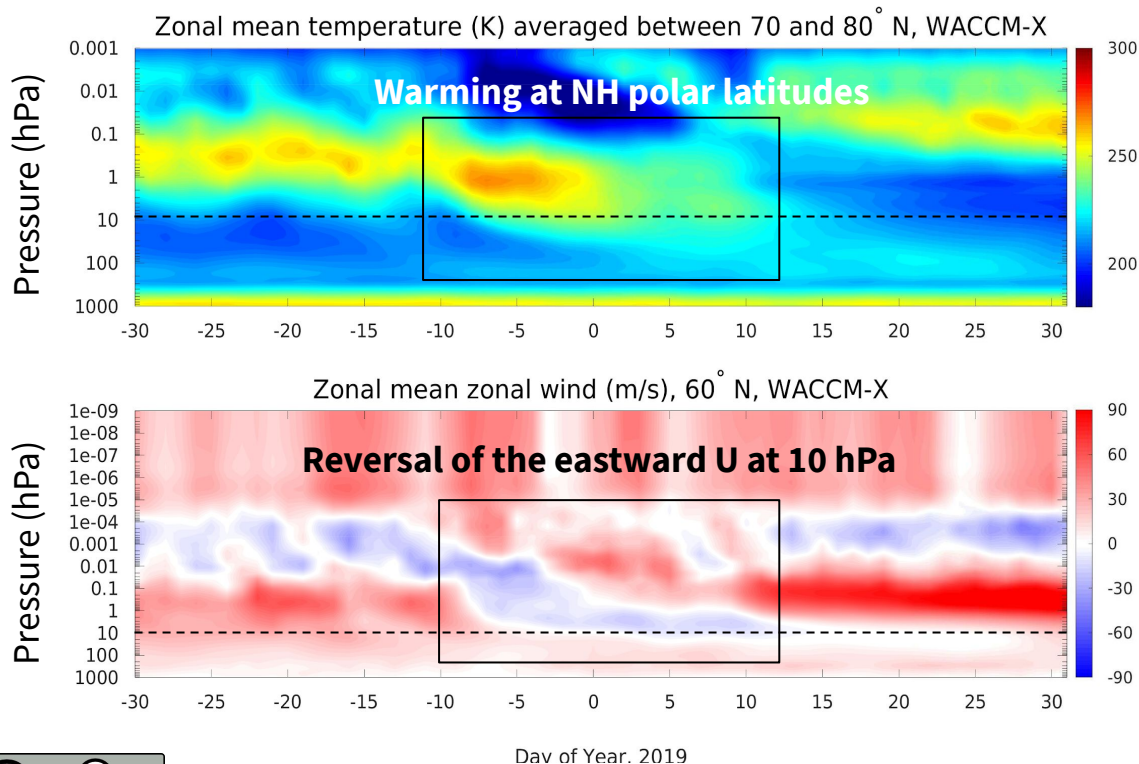
WACCM-X is a physics-based whole atmosphere general circulation model spanning from Earth's surface to upper thermosphere  
<https://www2.hao.ucar.edu/modeling/waccm-x>

Solves ionospheric electrodynamics using fully interactive dynamo solver



Jarvis, “**Bridging the Atmospheric divide**”,  
Science, Vol. 293, 2218-2219, 2001

# Simulating the 2019 SSW using WACCM-X



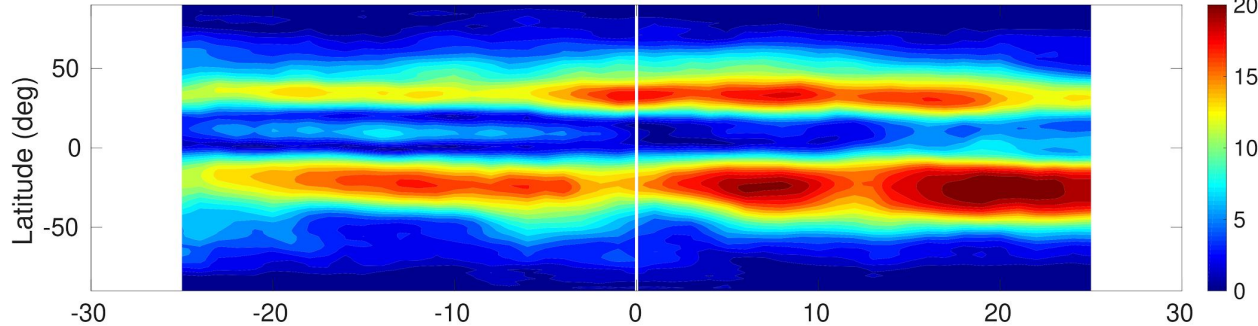
The 2019 SSW has been simulated using the **Specified Dynamics** configuration in WACCM-X

Winds, temperatures and geopotential height from **MERRA2** reanalysis have been used to nudge the model at each time step

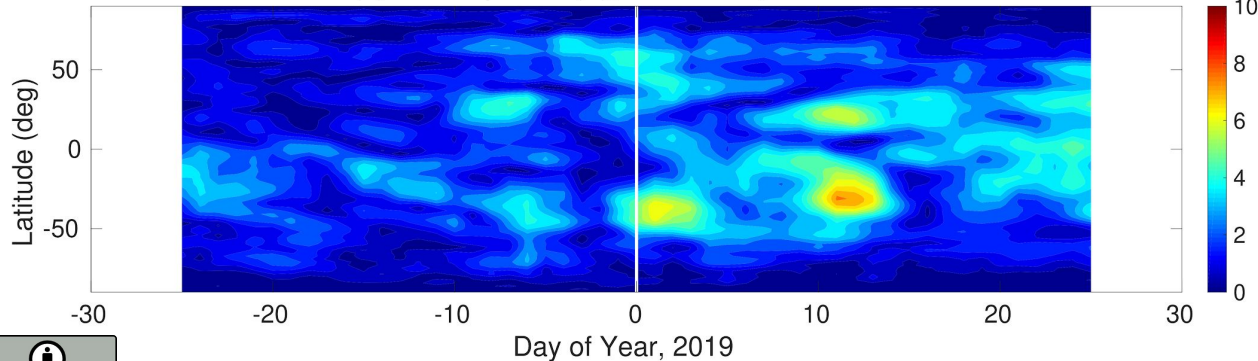
WACCM-X has been nudged to MERRA2 reanalysis from **0-50 km**

# SW2 and M2 tides in neutral temperature at 110 km

(a) SW2 amplitude (K), WACCM-X, 110 km



(b) M2 amplitude (K), WACCM-X, 110 km



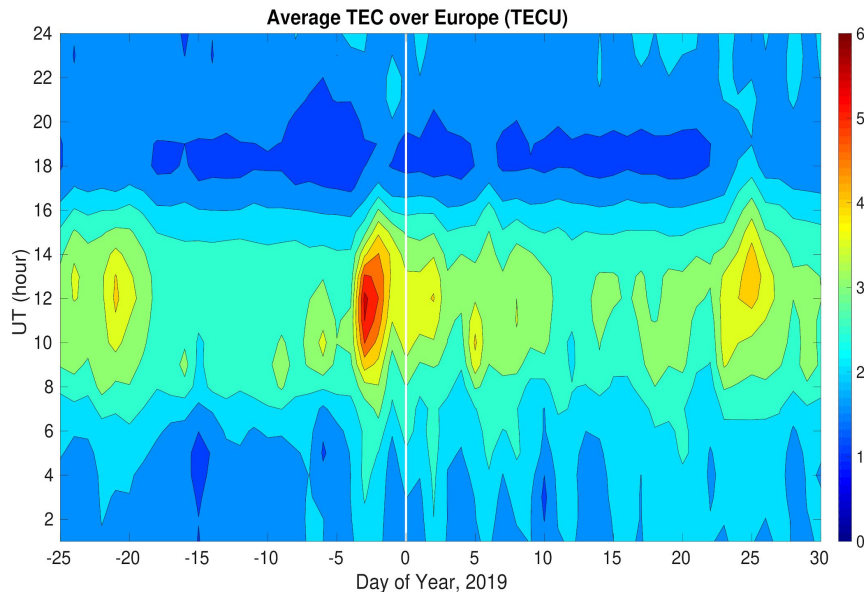
**Comparisons with the 2009 SSW events**

**Enhancement** of SW2 before and after the peak SSW day

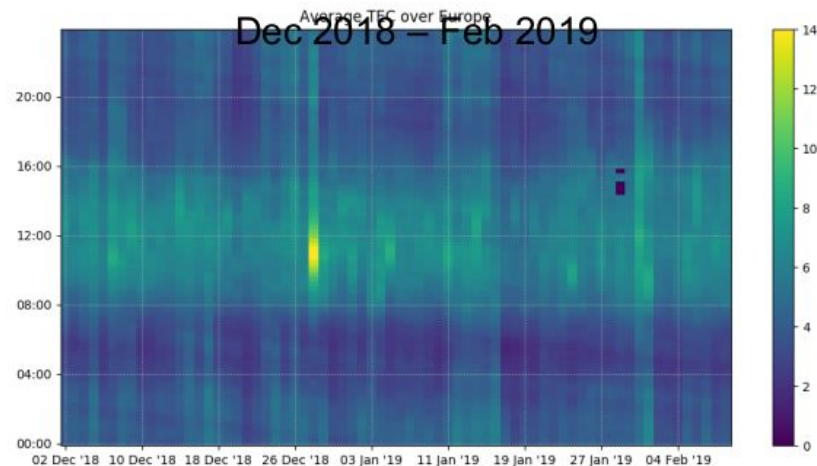
**Weakening** of SW2 during the peak SSW day

**Enhancement** of M2 during the warming

# TEC variability over Europe



WACCM-X



GPS observations

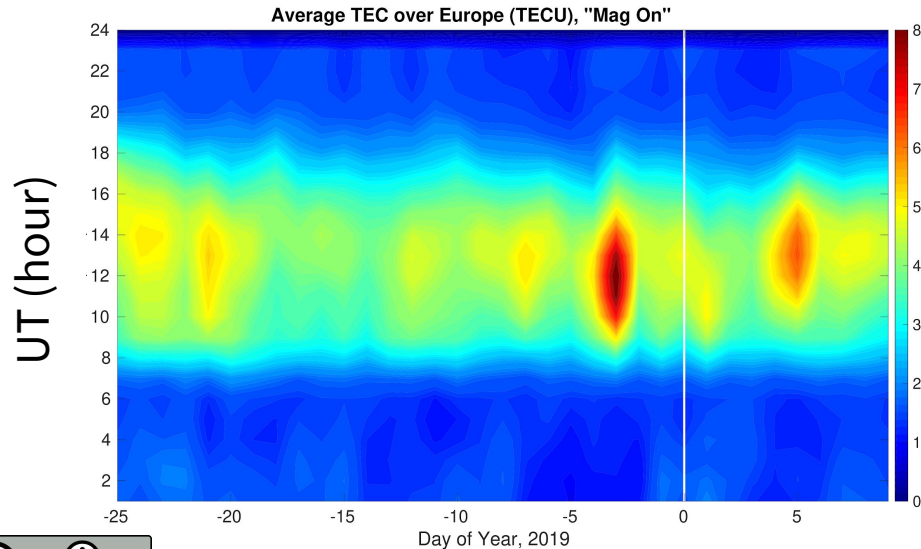
Enhancement of TEC is seen during the SSW onset in the European sector



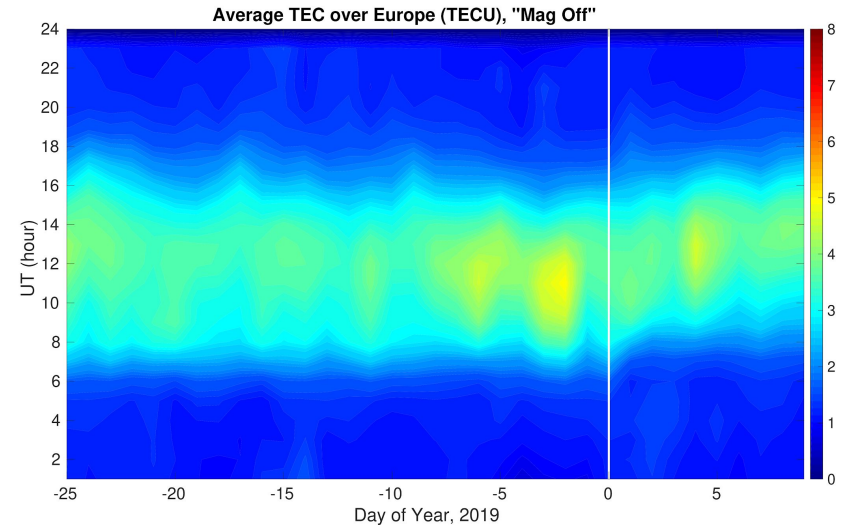
# Understanding the mechanisms of TEC variability

- TIE-GCM lower boundary is forced with WACCM-X outputs and we run two cases

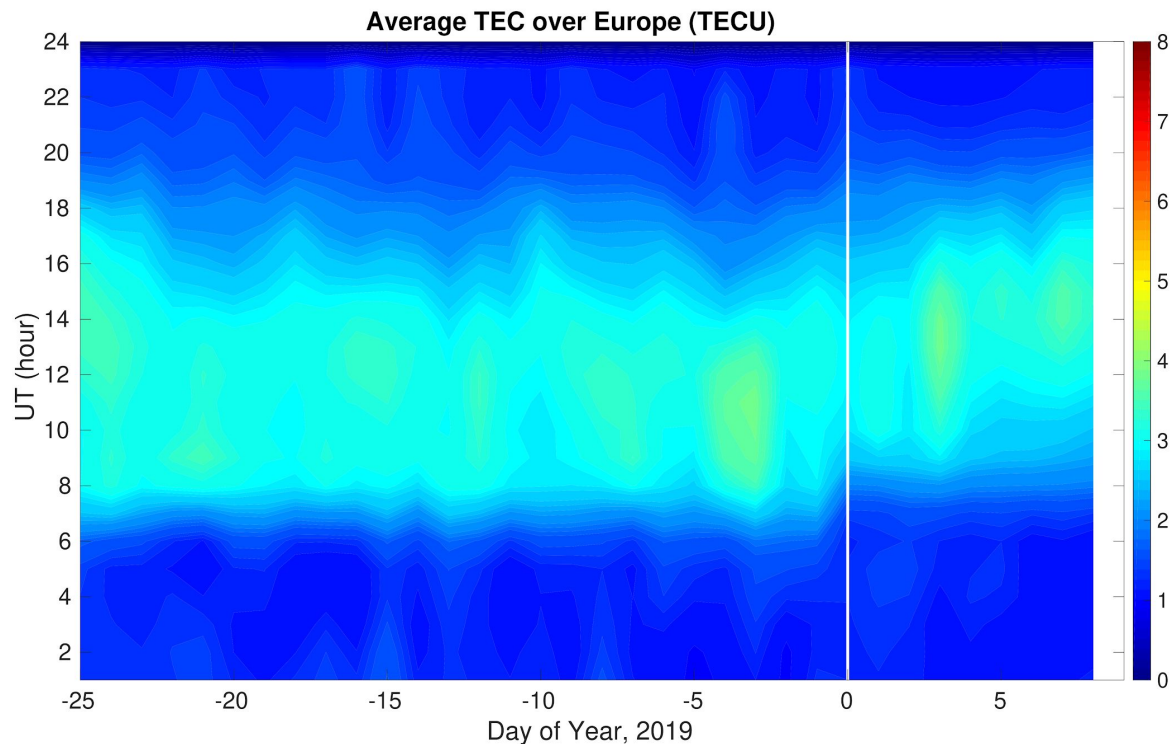
Magnetospheric Forcing on



Magnetospheric Forcing off



# Contributions to TEC variability from tides and planetary waves



Planetary Wave 1 and Migrating solar semidiurnal tide (SW2) have been removed from WACCM-X input files to TIE-GCM

The reduction in TEC variability indicates that PW1 and SW2 are main components of lower atmospheric forcing



# Conclusions

- SW2 and M2 enhancements seen during the 2019 SSW event
- TEC enhancement over Europe during the 2019 SSW occurs due to combined effects of both **geomagnetic** and **lower atmospheric** forcing
- PW1 and SW2 are the main lower atmospheric forcing components that contribute to TEC enhancement over Europe