



# Relationships between solar wind parameters and the total electron content (TEC)

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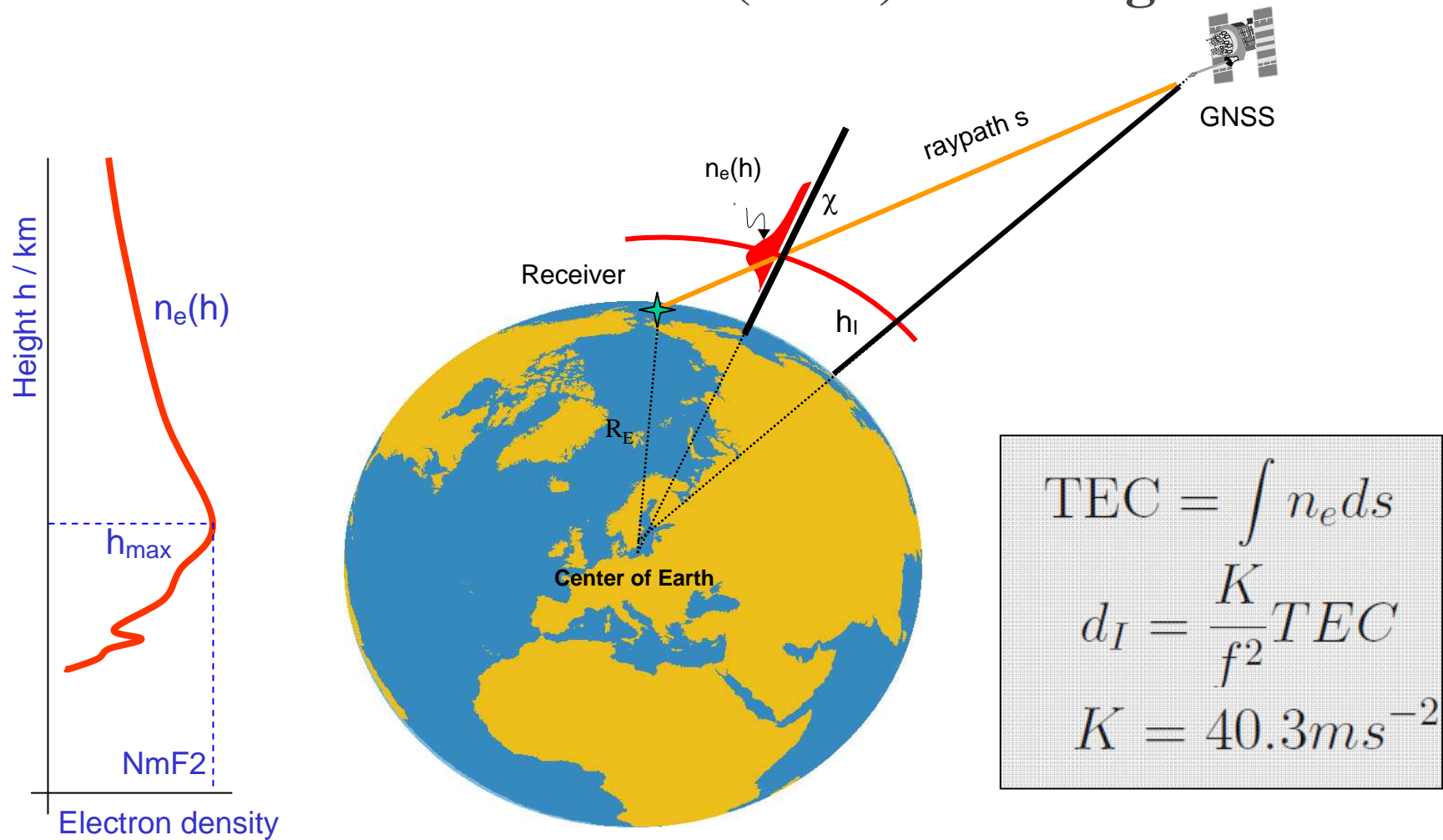
AGU Chapman Conference,  
Charleston S.C. 9-12 May 2011



# Outline

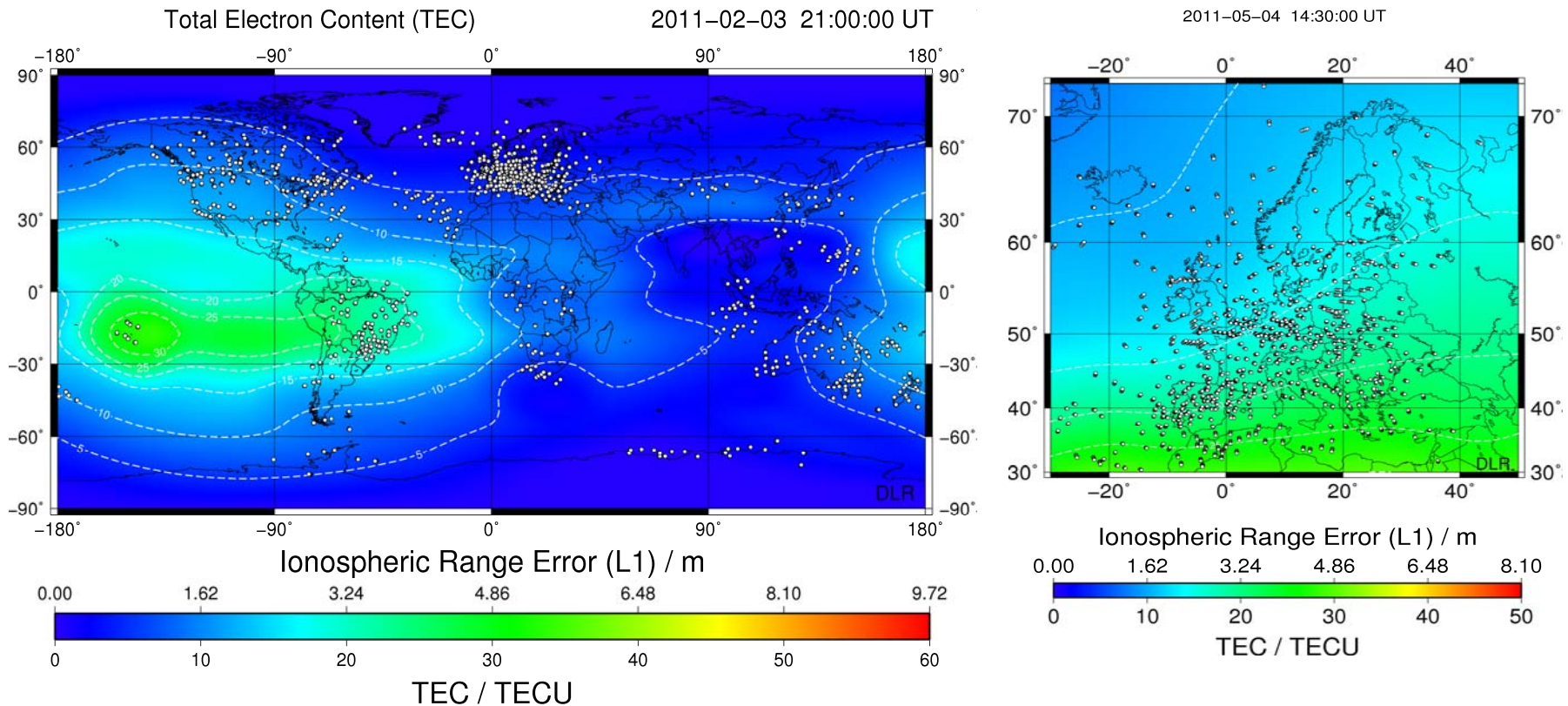
- Introduction
- Parameters and the method
- Storms on May 2005 and Dec 2006
- Correlation functions
- Conclusions

# Total electron content (TEC) and range error





# Total electron content monitoring



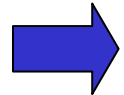
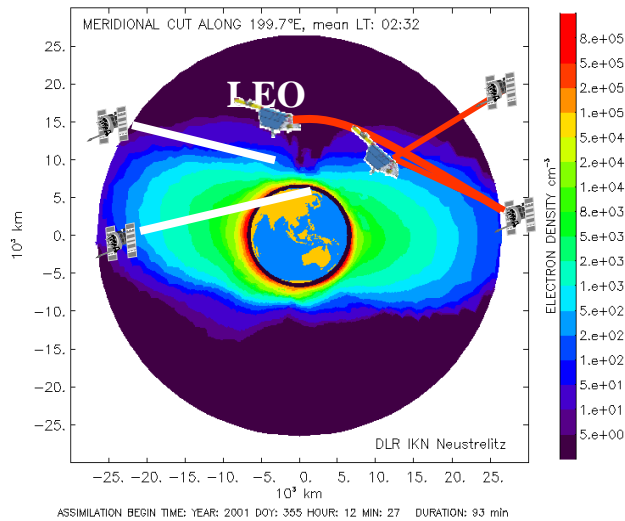
\* N. Jakowski, E. Sardon, S. Schlueter, Adv. in Space Res., 22, 803-806, 1998.

\*\* N. Jakowski, C. Mayer, M.M. Hoque, V. Wilken, submitted

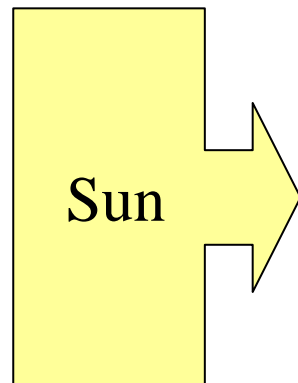
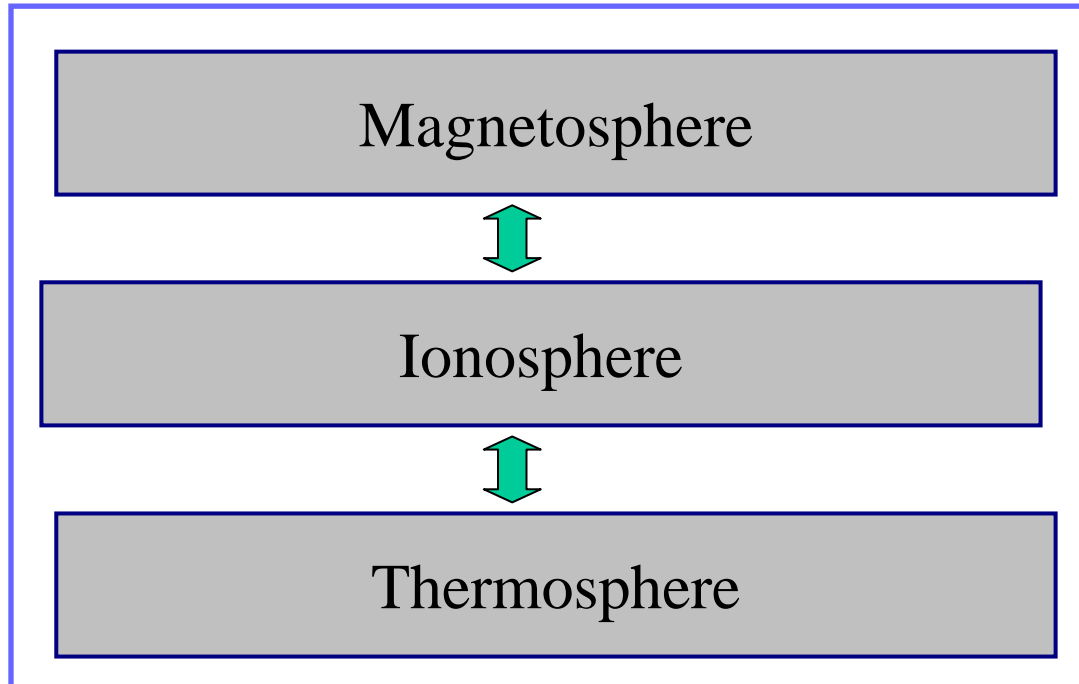
<http://swaciweb.dlr.de/>



# TEC modeling and warning



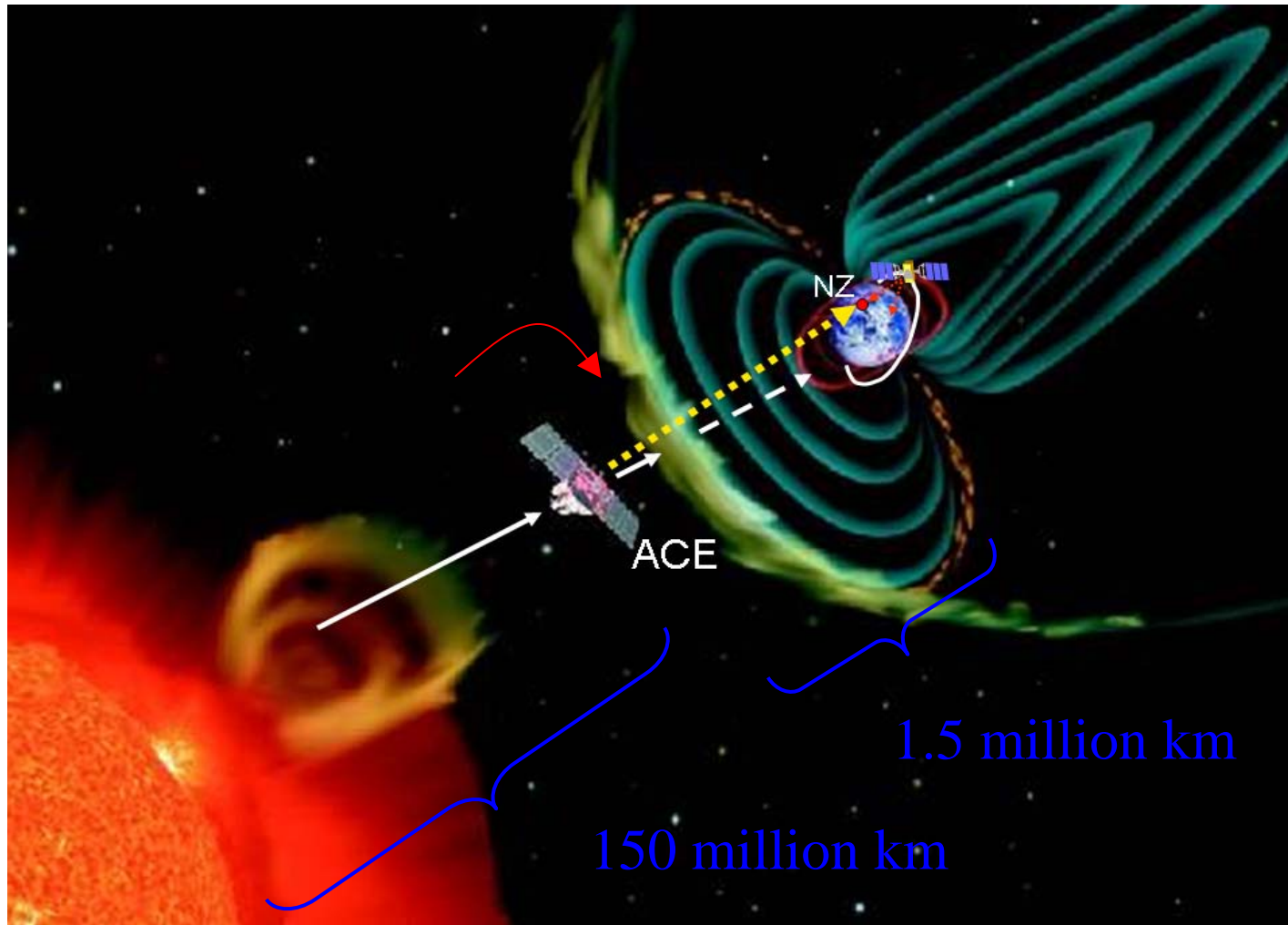
Initial 3D Ionosphere



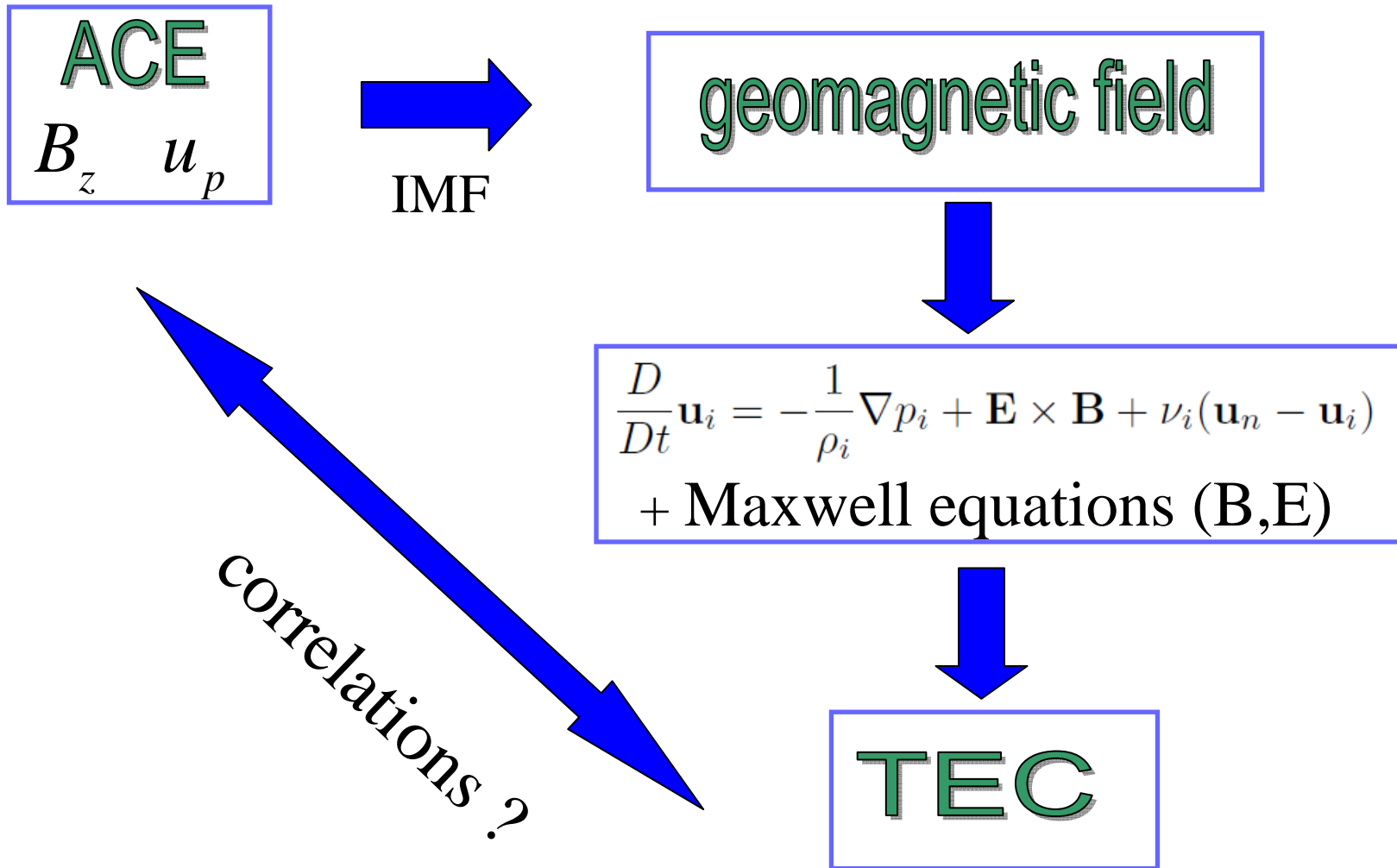
solar activity (F10.7, ACE)



# Advanced Composition Explorer



# What are the generic features ?



# Methods, data and parameters

TEC data, hourly

$$\Delta\text{TEC} = \frac{\text{TEC} - \text{TEC}_{\text{med}}}{\text{TEC}_{\text{med}}} 100\%$$

solar wind parameters, hourly

$$B_z \quad w = \rho v^2 / 2$$

correlation function

$$C_{XY}(\tau) = \frac{\langle (X(t) - \bar{X})(Y(t+\tau) - \bar{Y}) \rangle}{\langle (X(t) - \bar{X})(Y(t) - \bar{Y}) \rangle}$$

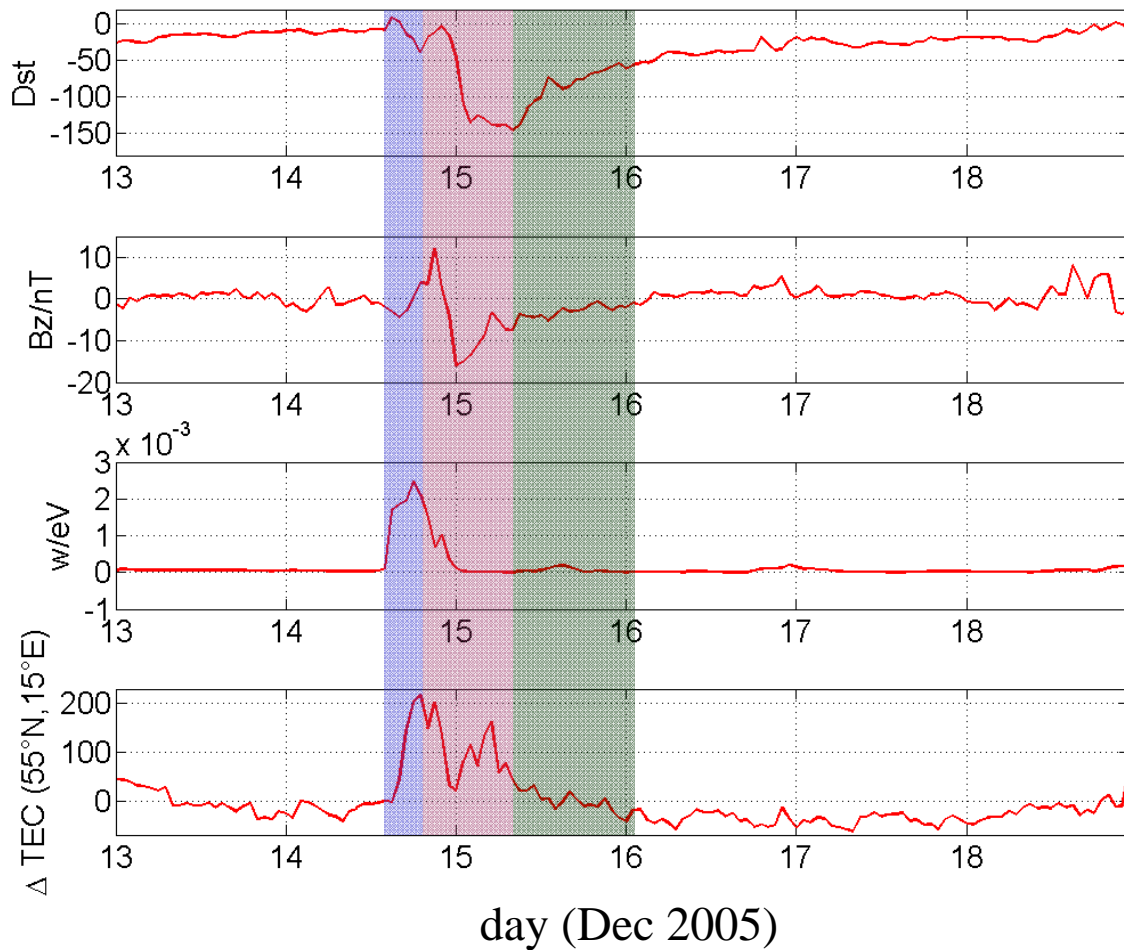
$$\bar{X}(t) = \langle X(t) \rangle$$







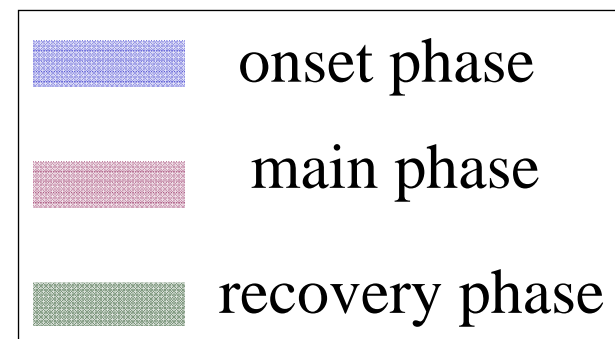
# TEC response: Winter



CME : X3-class explosion  
on Dec. 13th.

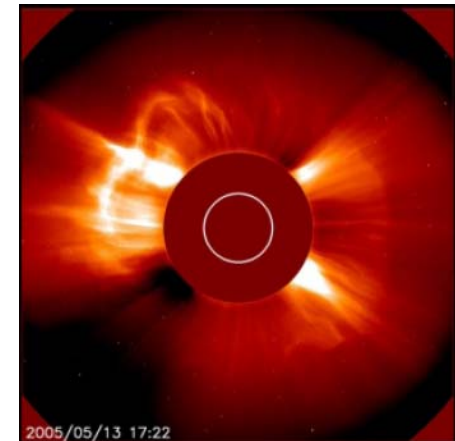
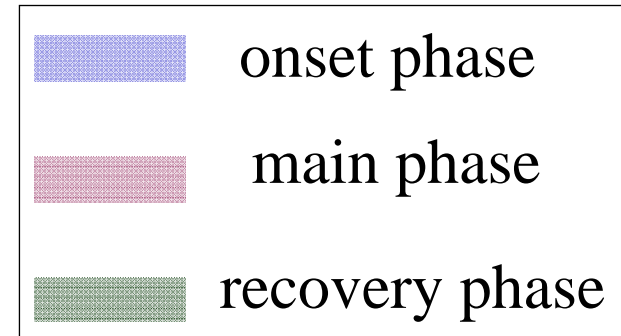
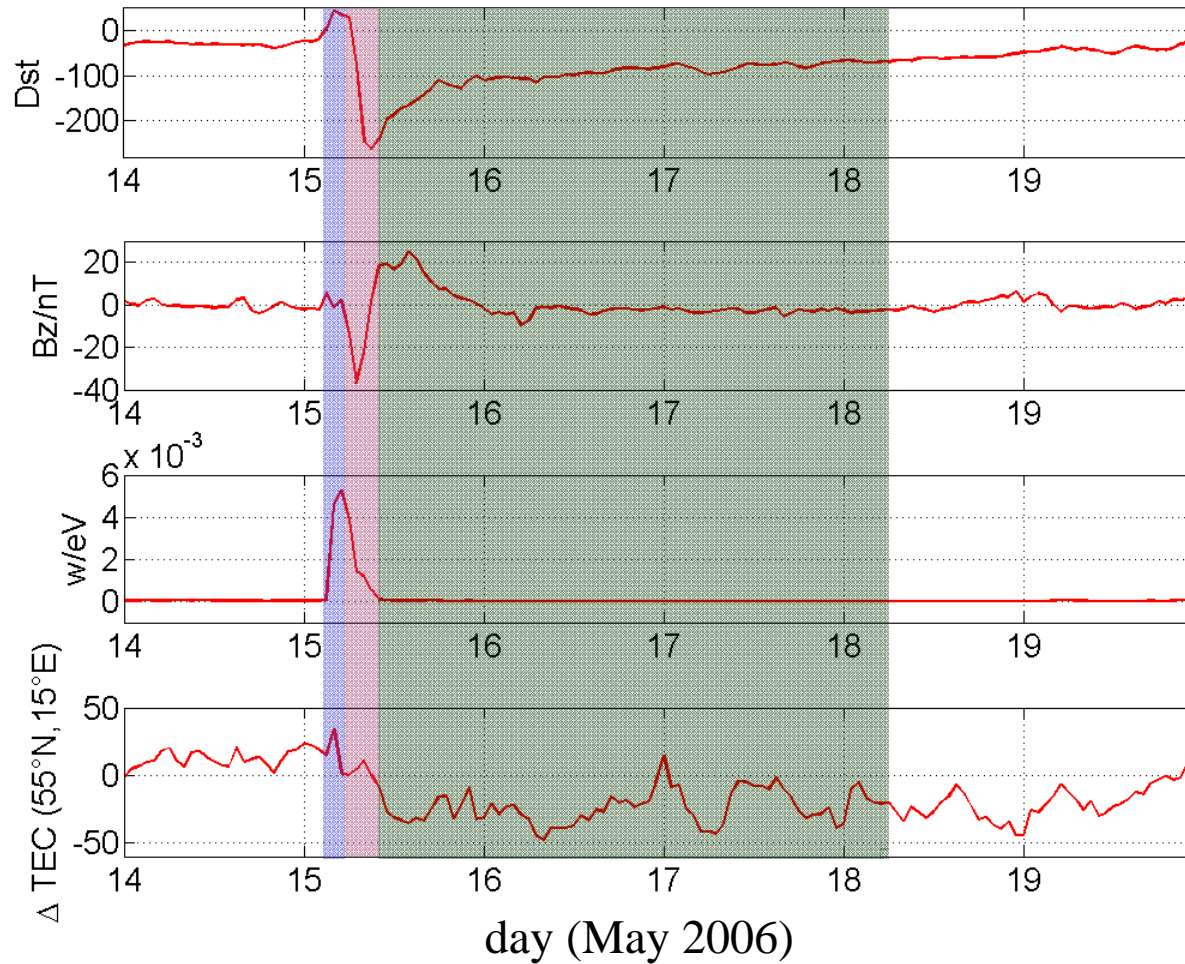


Dec. 15, 2006, Juliusson, near Reykjavik





# TEC response: Summer

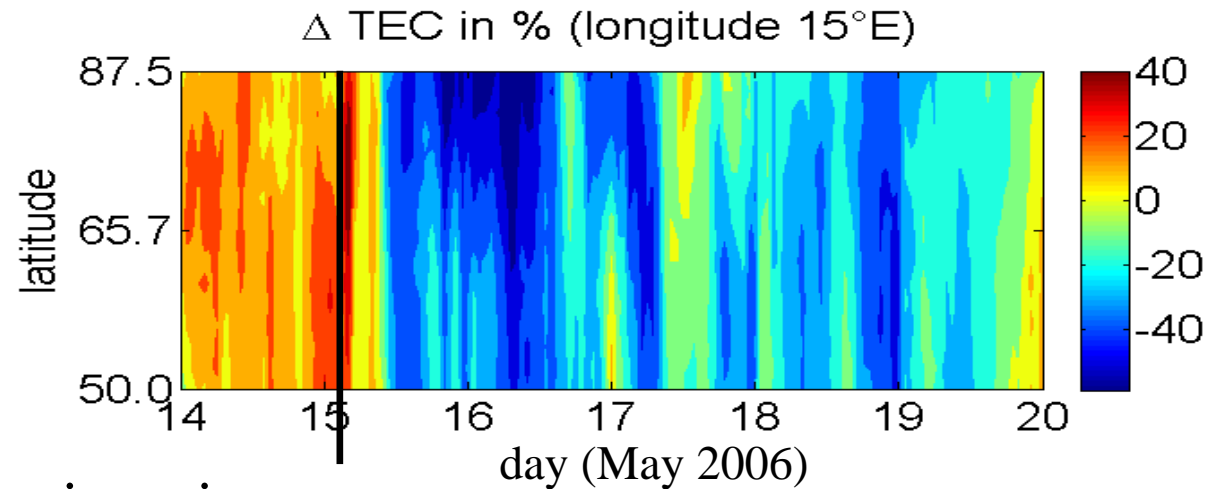


SOHO 2005/05/13

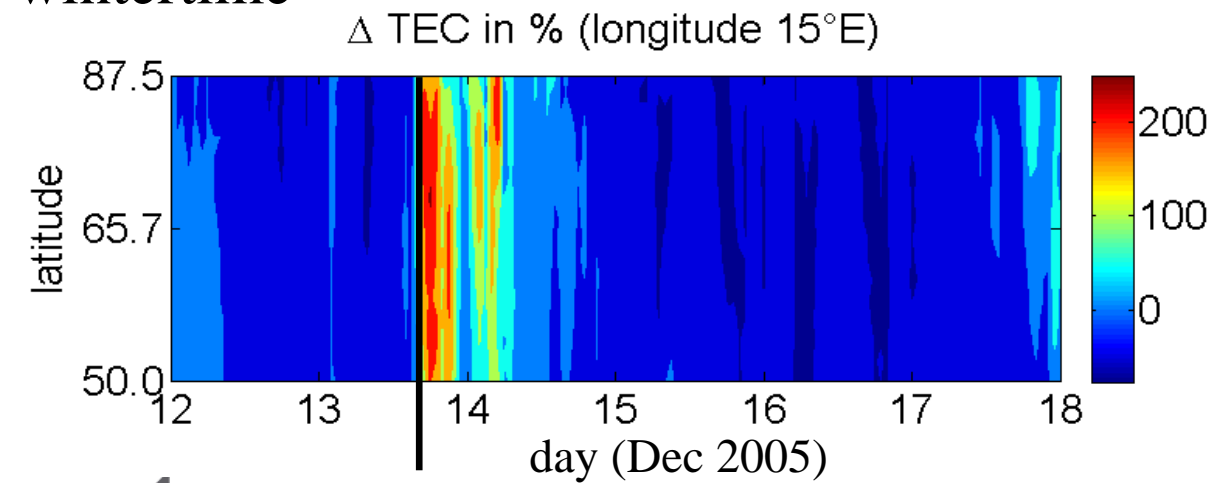


# Storm time pattern of TEC

summertime



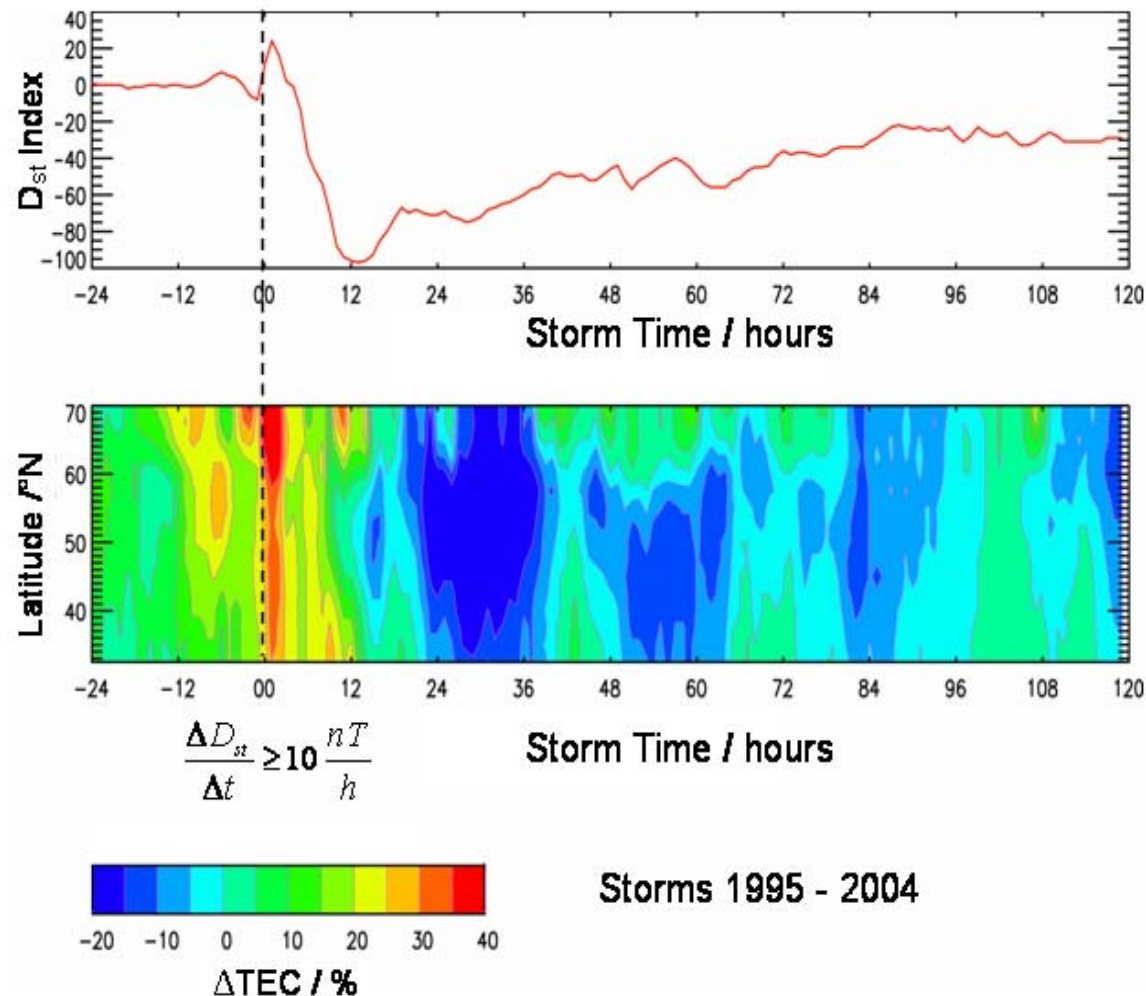
wintertime



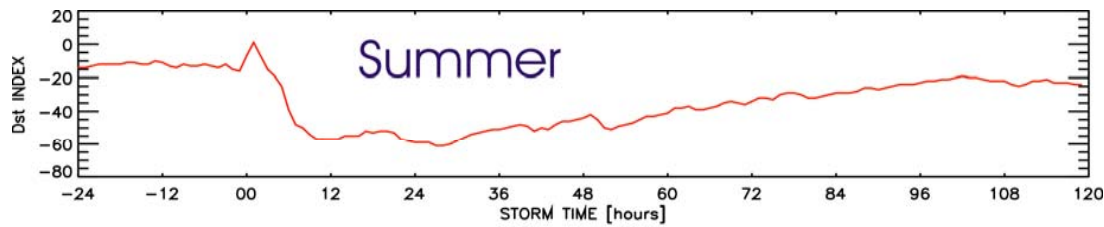
summer:  
negative phase  
winter:  
positive phase



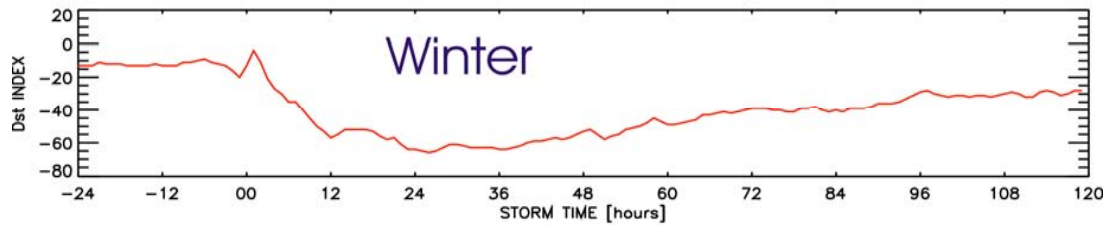
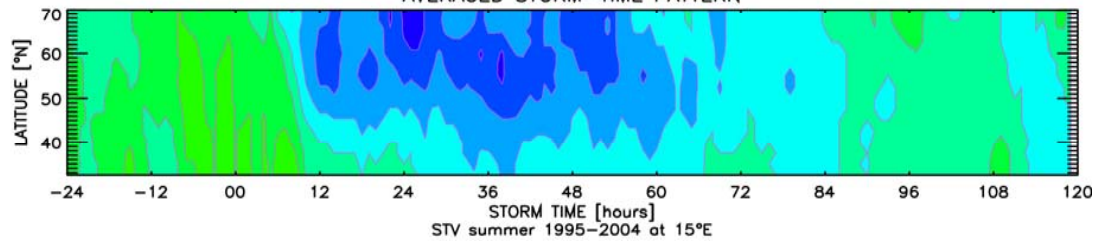
# Percentage storm time pattern of TEC-rapid onset



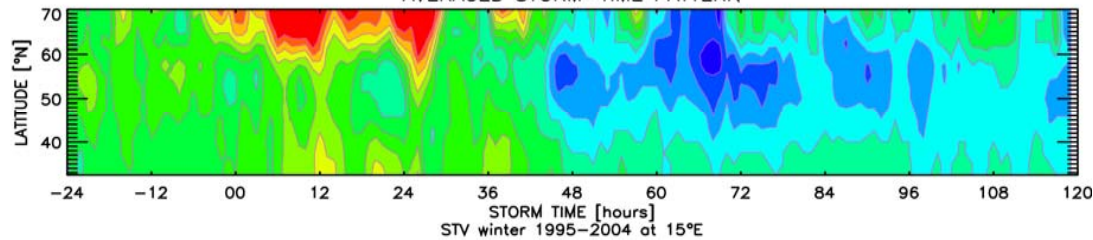
- Definition of storm time and selection criteria crucial
- Storms with rapid onset selected for superposed epoch analysis
- Simultaneous enhancement of TEC at all latitudes along the selected meridian



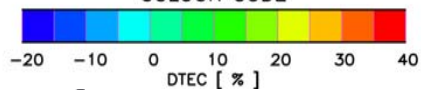
AVERAGED STORM-TIME PATTERN



AVERAGED STORM-TIME PATTERN



COLOUR CODE



Summer: 24 storms  
 Winter: 30 storms  
 (1995-2004)

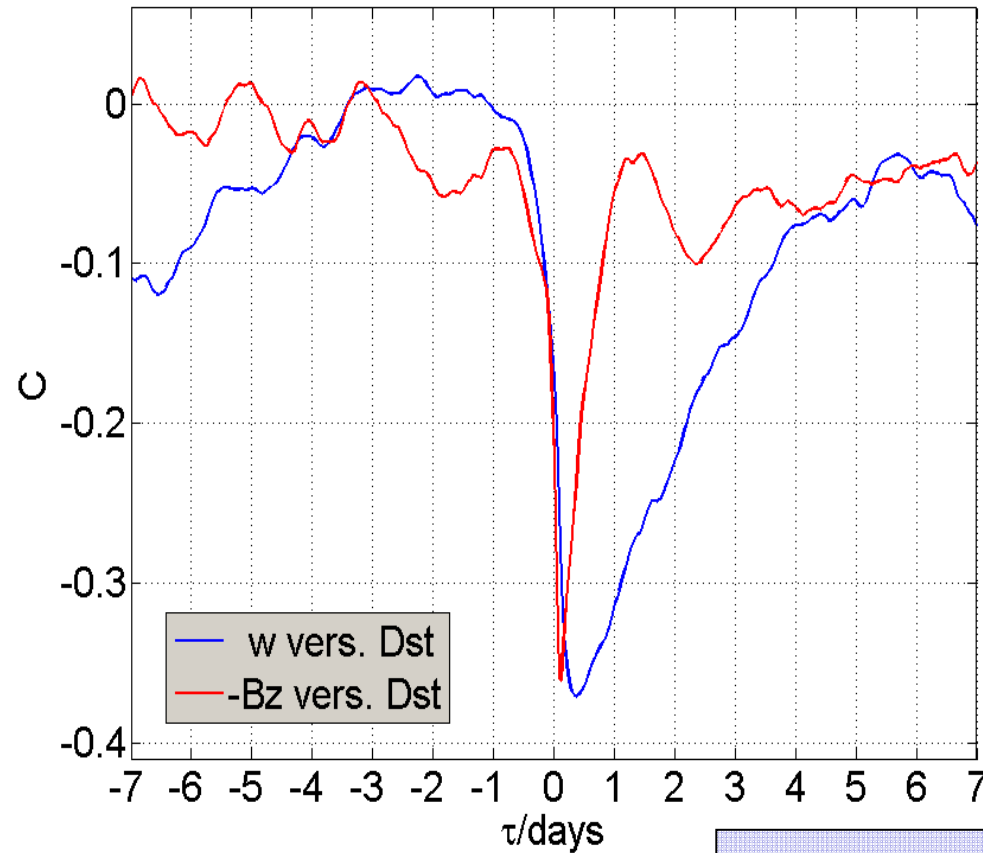
Storms with rapid onset  
 selected for superposed  
 epoch analysis

B. Arbesser-Rastburg and N. Jakowski,  
 in Space Weather – Physics and Effects



# Correlation functions

years 2004-2009

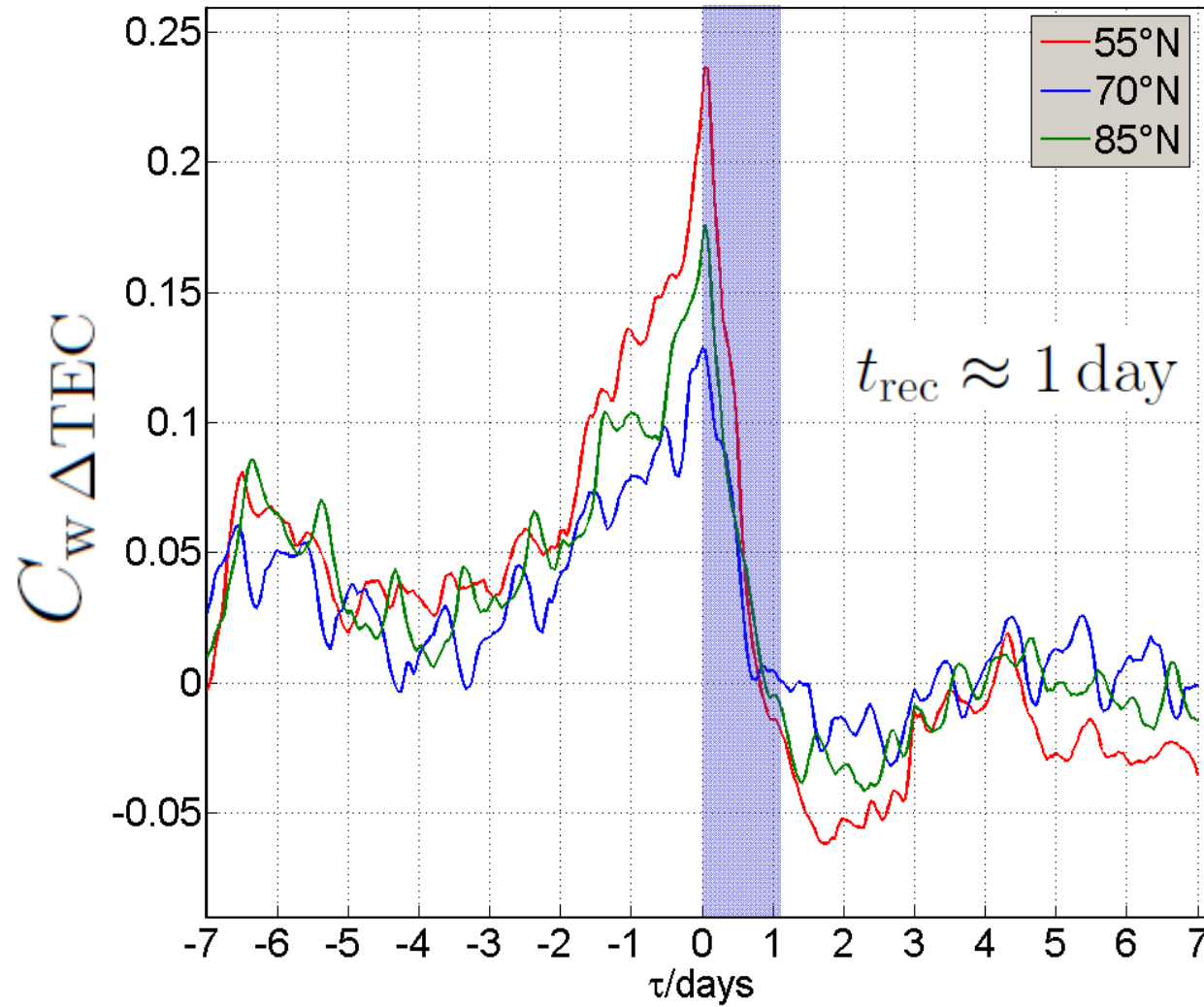


includes all events

$$C_{XY}(\tau) = \frac{\langle (X(t) - \bar{X})(Y(t+\tau) - \bar{Y}) \rangle}{\langle (X(t) - \bar{X})(Y(t) - \bar{Y}) \rangle}$$

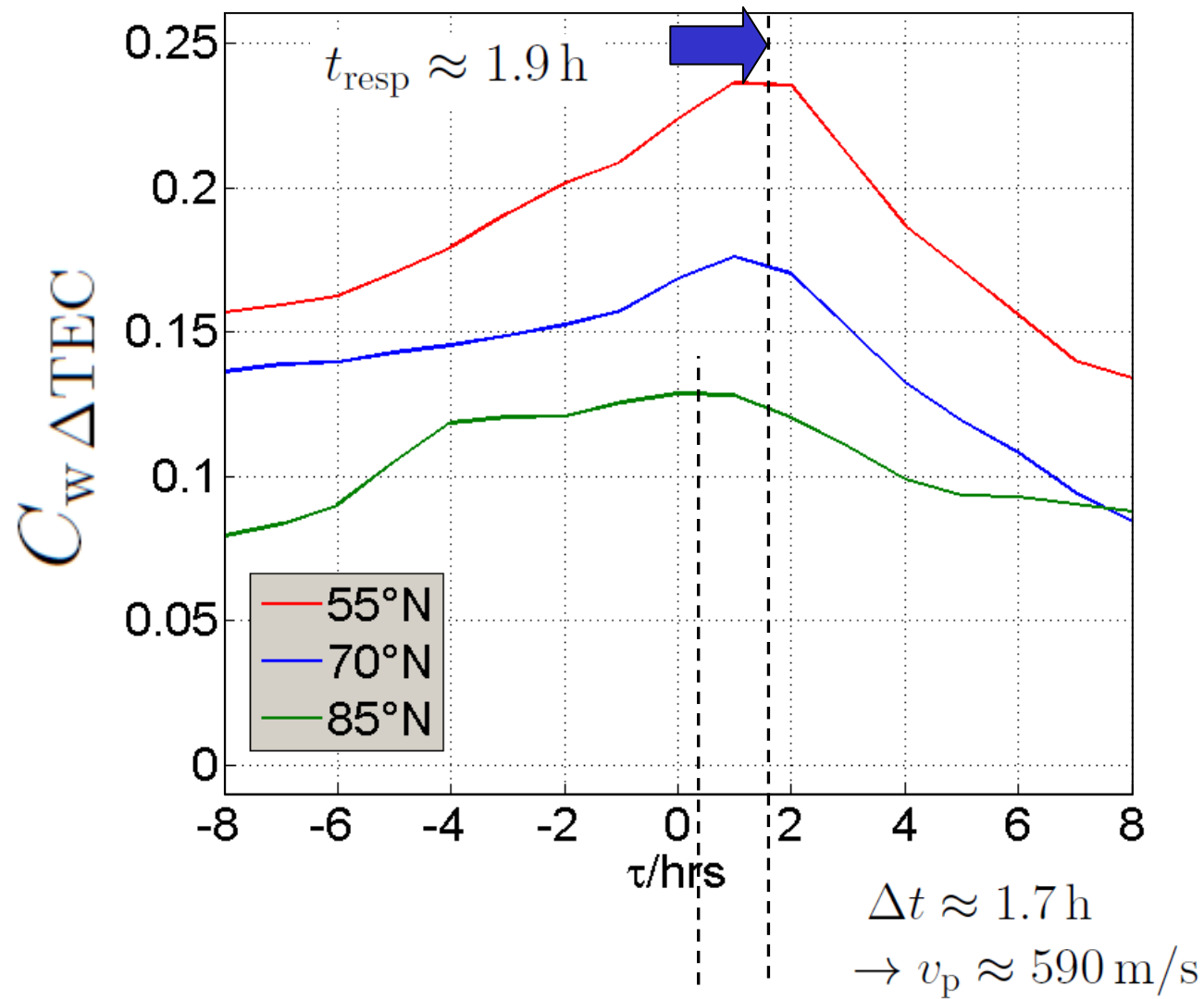


winter 2004-2009 (15°E)





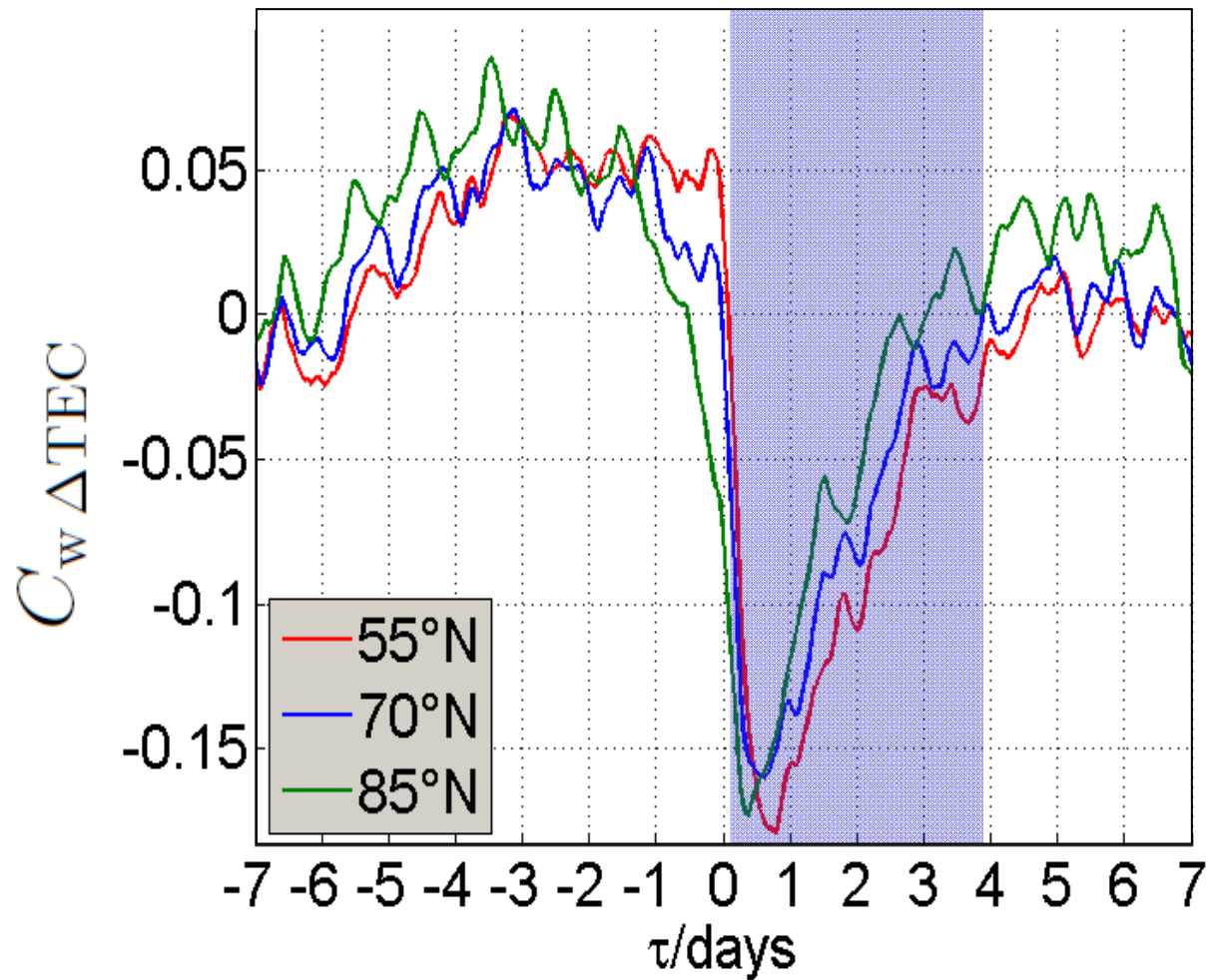
winter 2004-2009 (15°E)







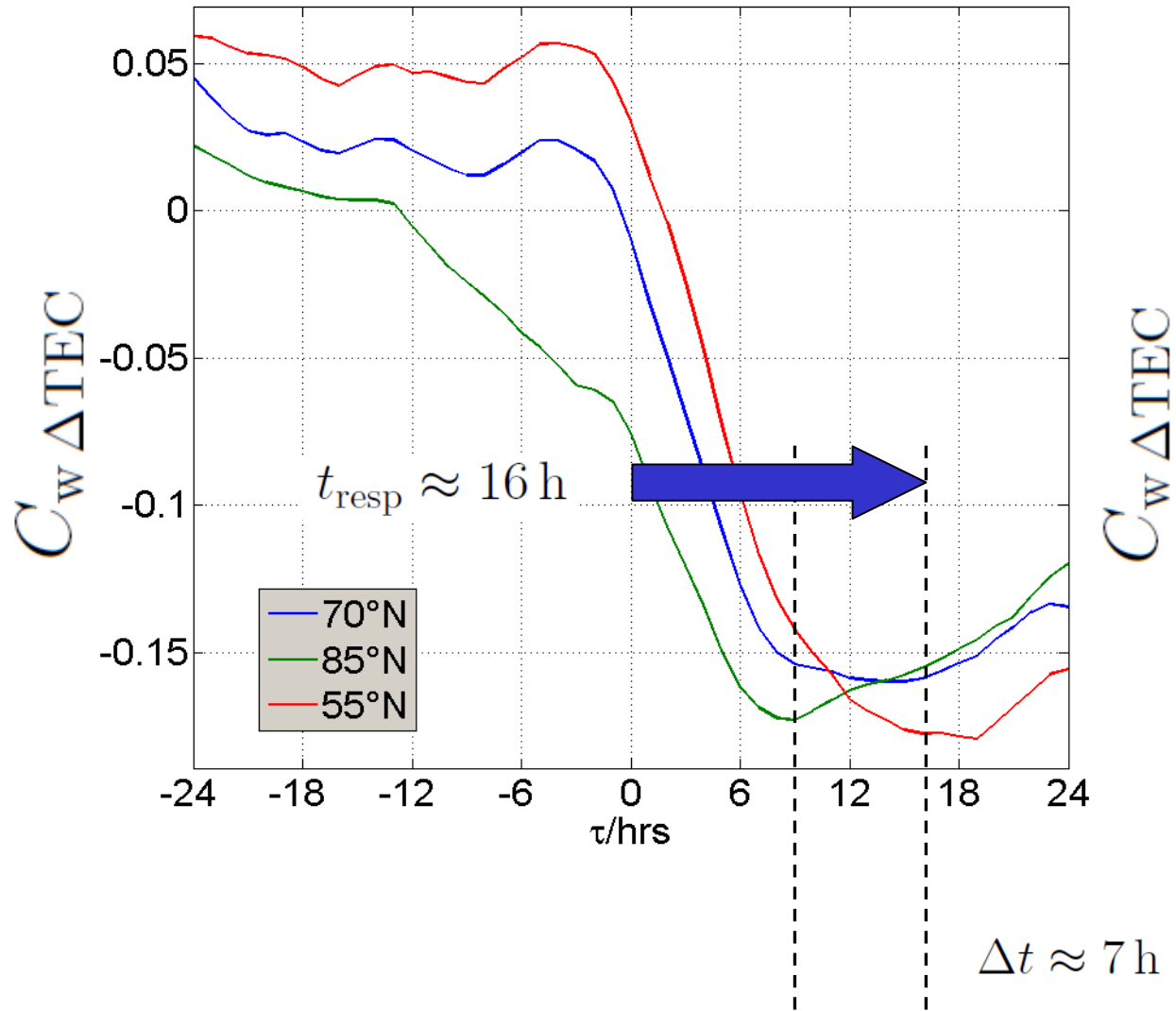
summer 2004-2009 (15°E)



$t_{\text{rec}} \approx 3.8 \text{ days}$




summer 2004-2009 (15°E)





# Conclusion

- 
- Summer:
- negative correlation
  - long recovery times
  - low perturbation propagation velocities
  - high response times
- Winter:
- positive correlation
  - short recovery times
  - high perturbation propagation velocities
  - low response times



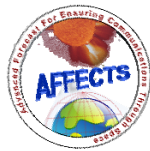
# Acknowledgement

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Thank you for your attention!