Doing Space Weather

by using ground-based optical instruments in the polar region

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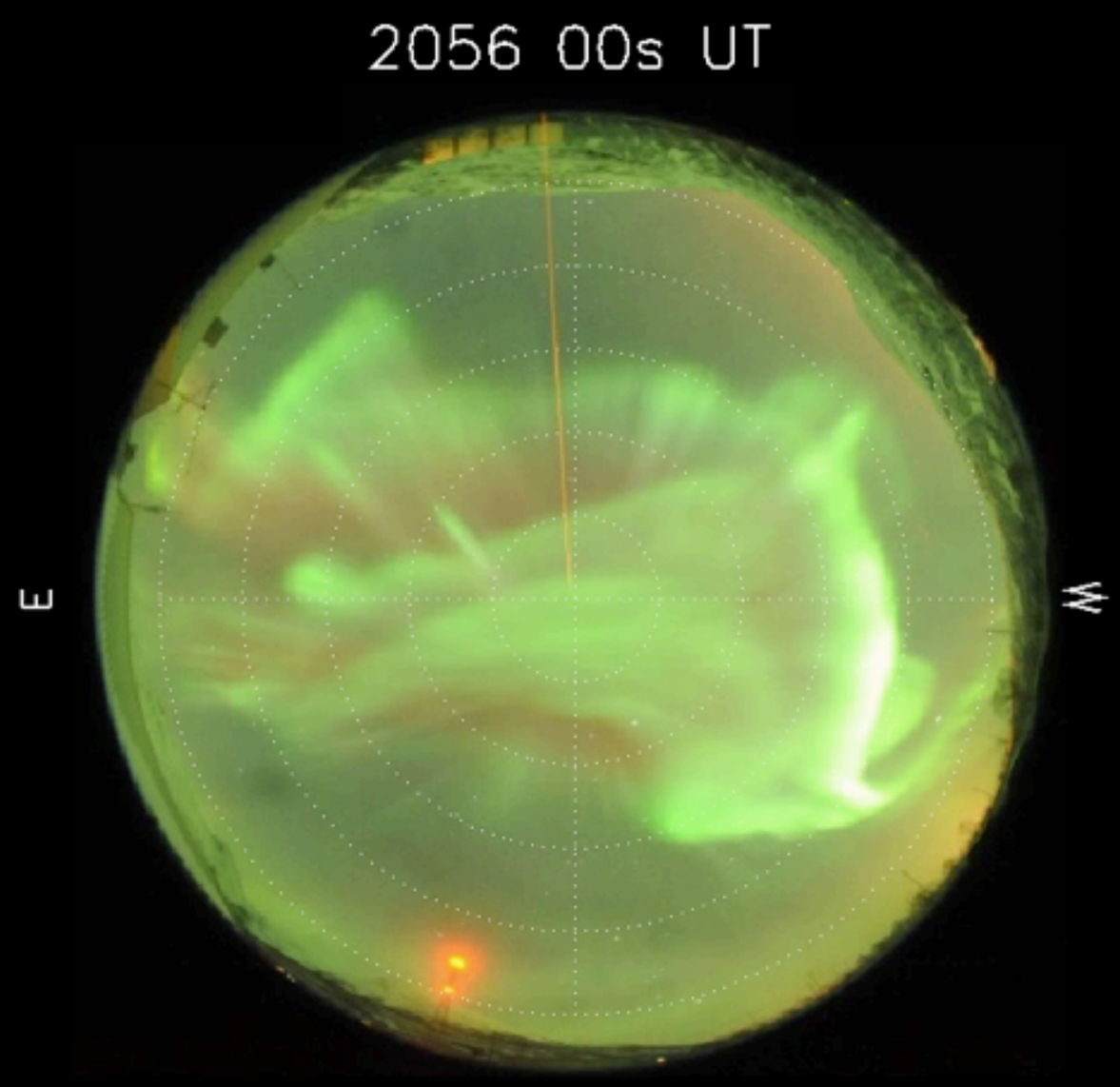
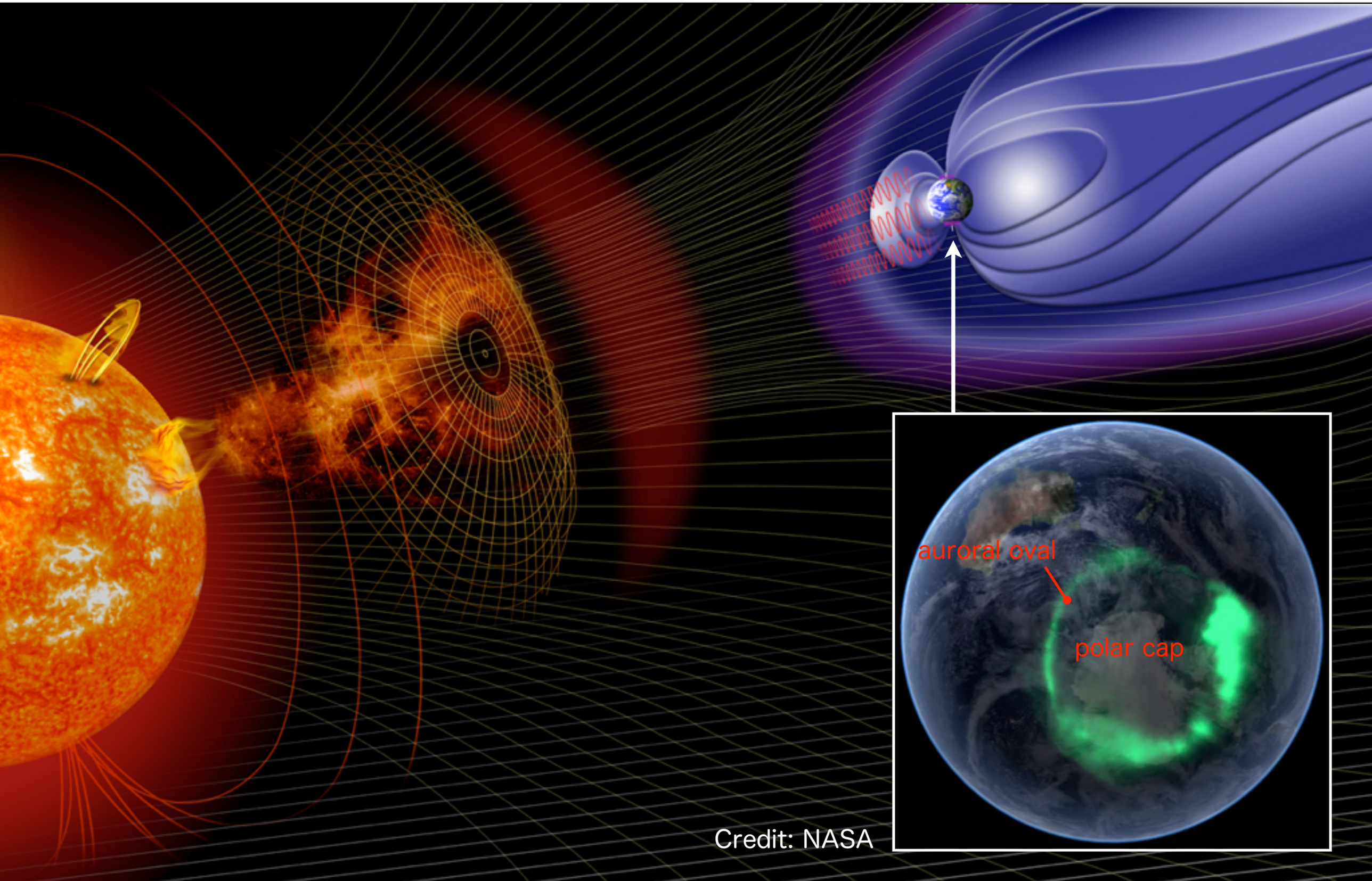


True-colour all-sky auroral images
from Tromsø, Norway

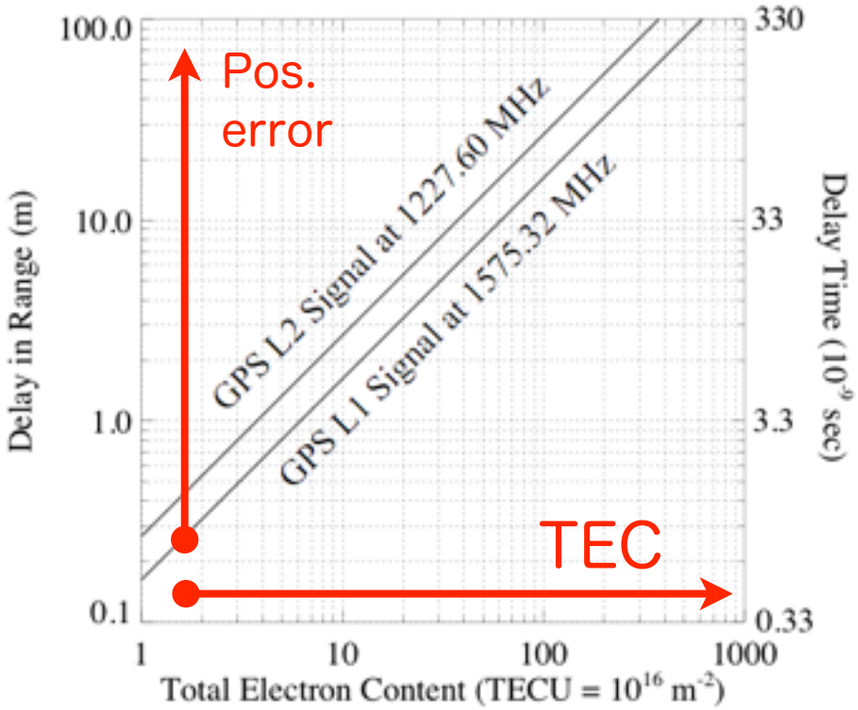
“Space weather” and “polar ionosphere”



Credit: NASA

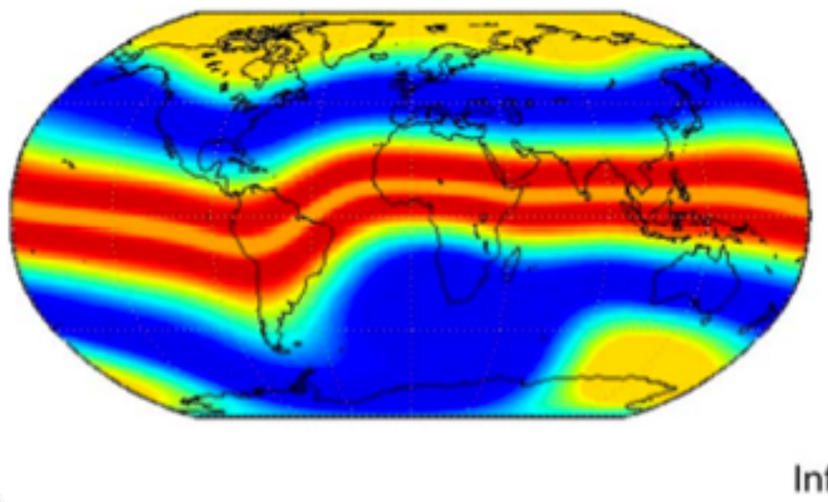
What is the SW impact of ionosphere?

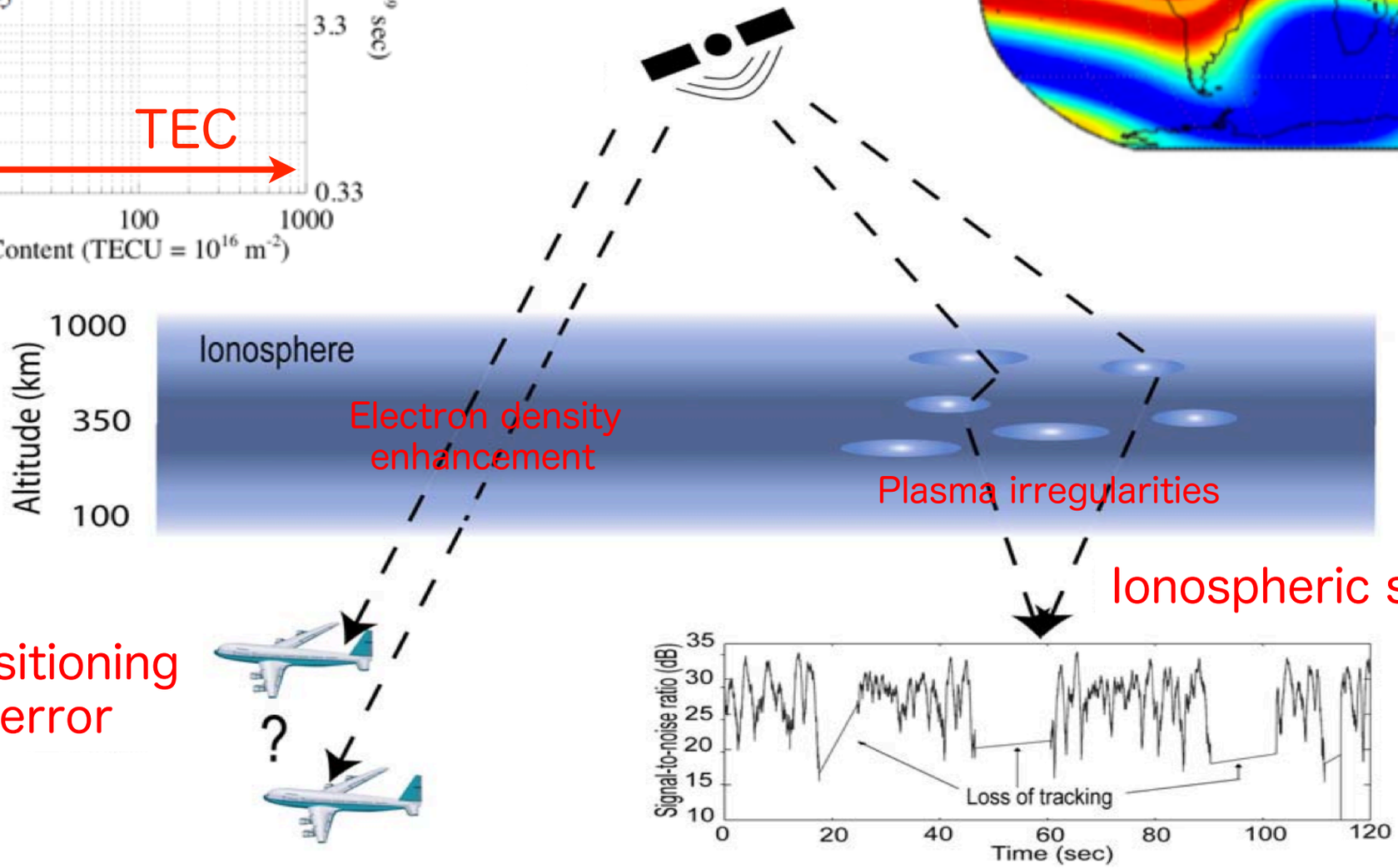
Satellite communication environment is dependent on the status of the ionosphere.



GNSS

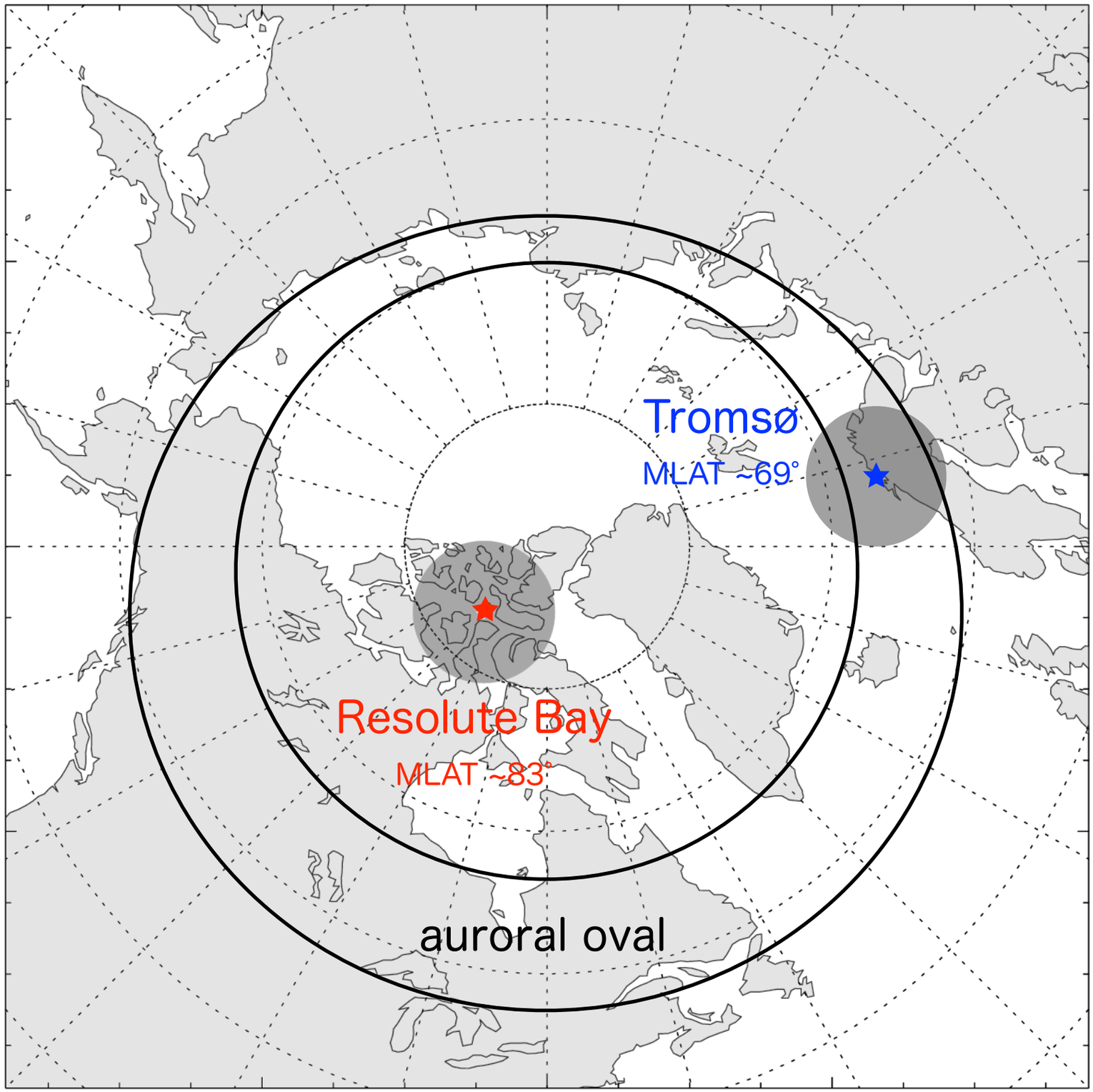
(Global Navigation Satellite System)

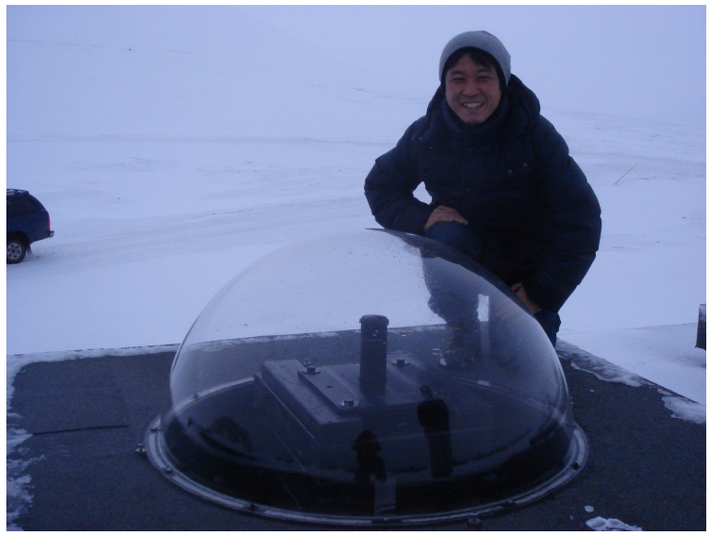




Kintner, 2008

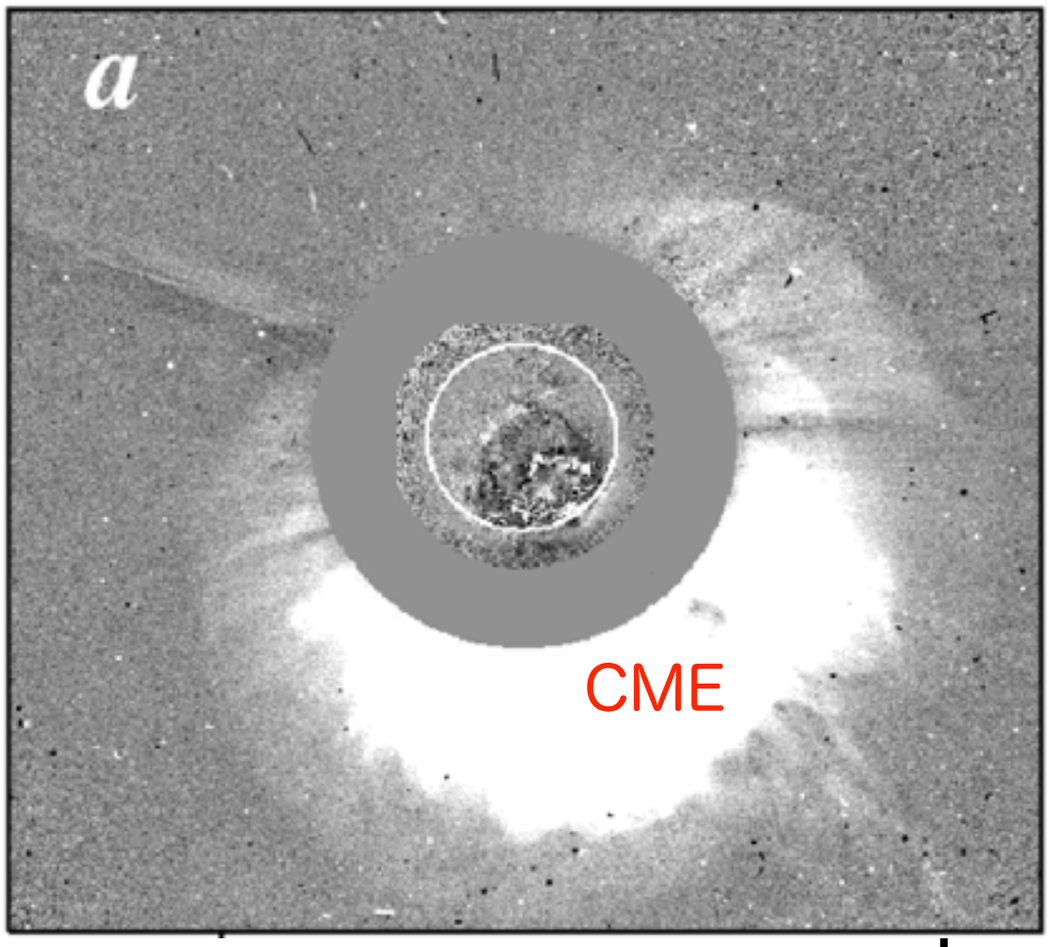
Optical observations in the polar region



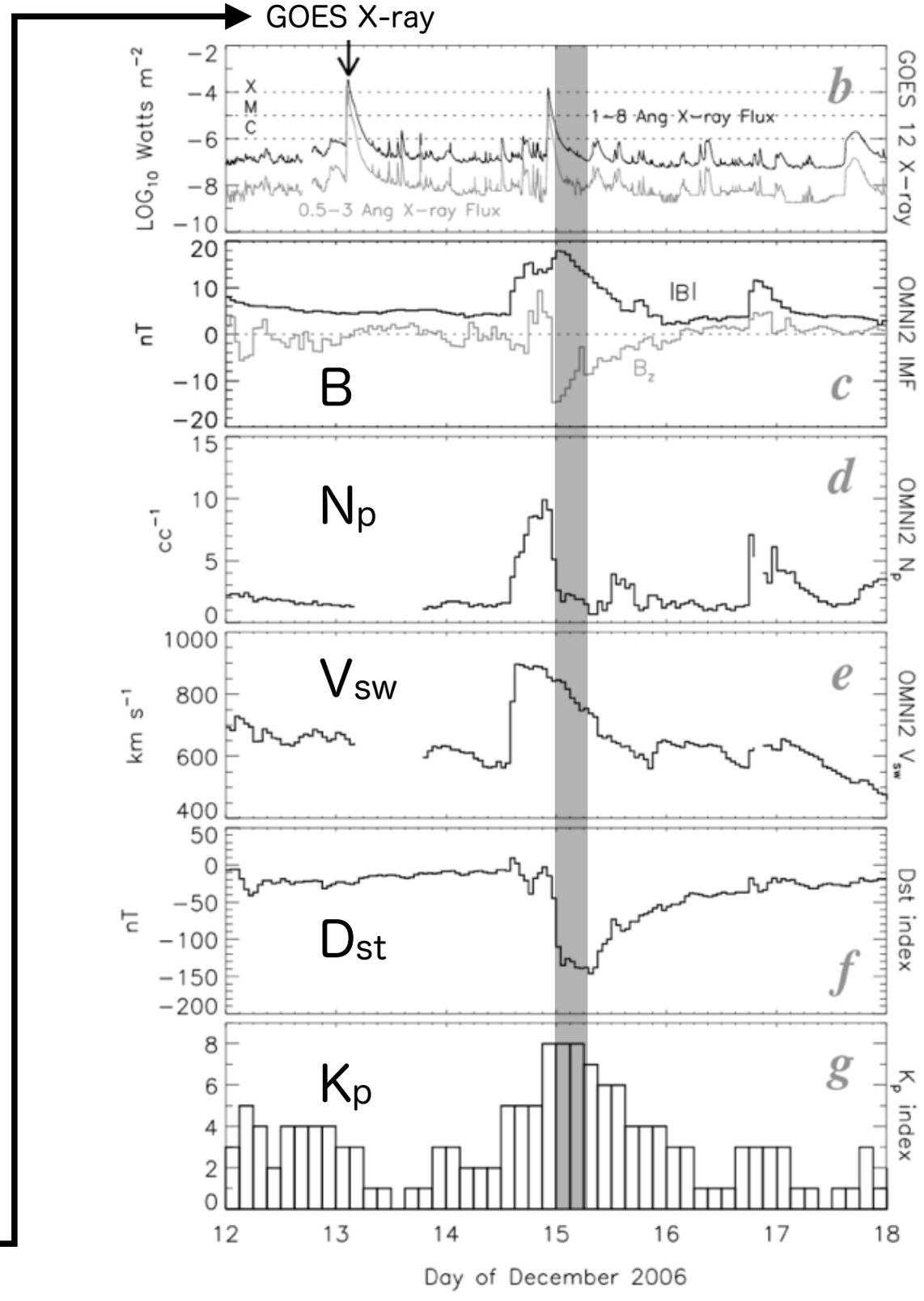


A magnetic storm on Dec 15, 2006

- ❖ X class flare and CME on Dec 13, 2006
- ❖ Shock arrived at ACE on Dec 14, 2006
- ❖ Increased magnetic field ~20 nT
- ❖ Increased solar wind density and speed
- ❖ Large magnetic storm (min D_{st} -146 nT)



SOHO LASCO + EIT



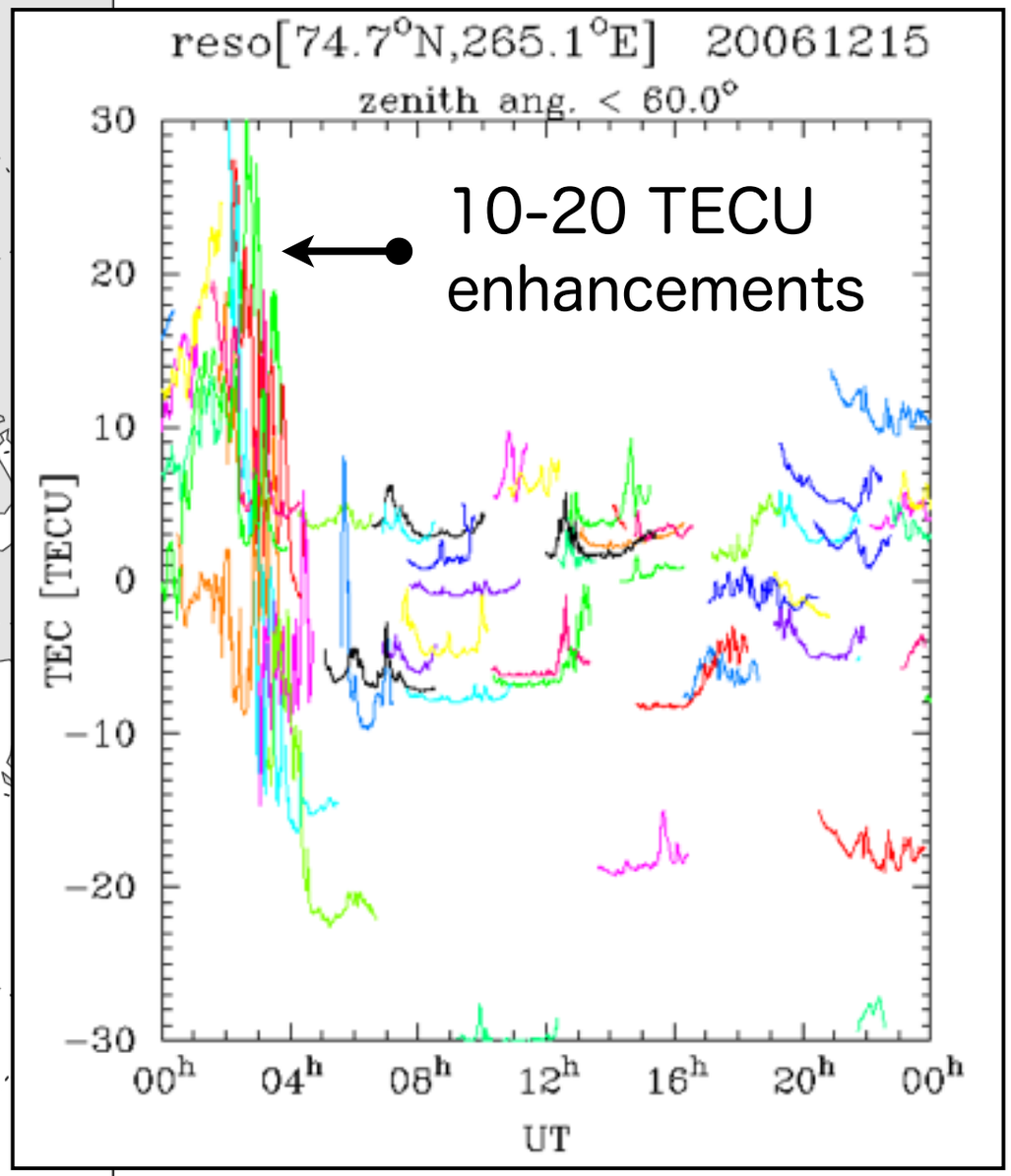
TEC enhancements in the polar cap

Resolute Bay

MLAT ~83°

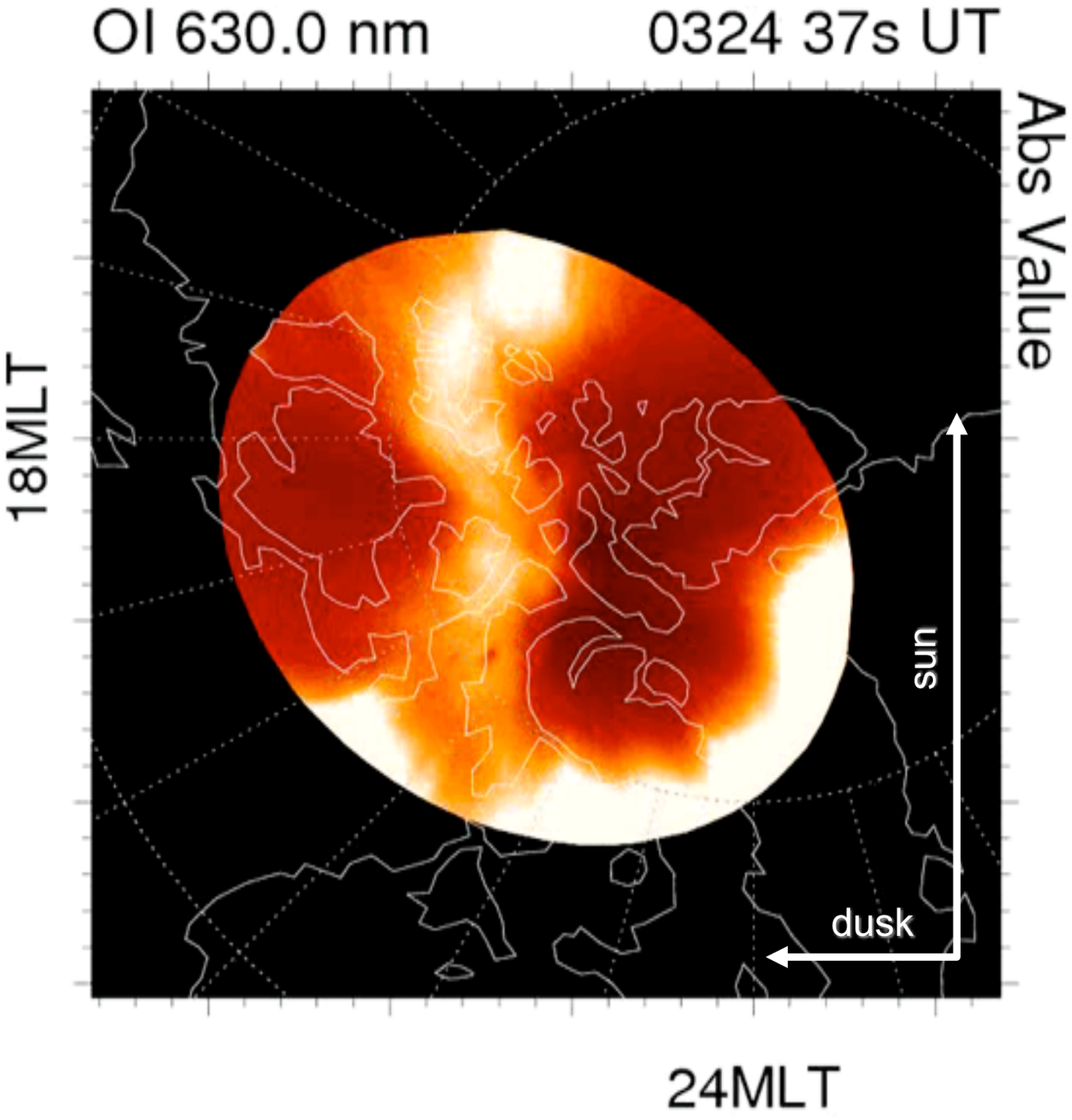
auroral oval

TEC data from Resolute Bay

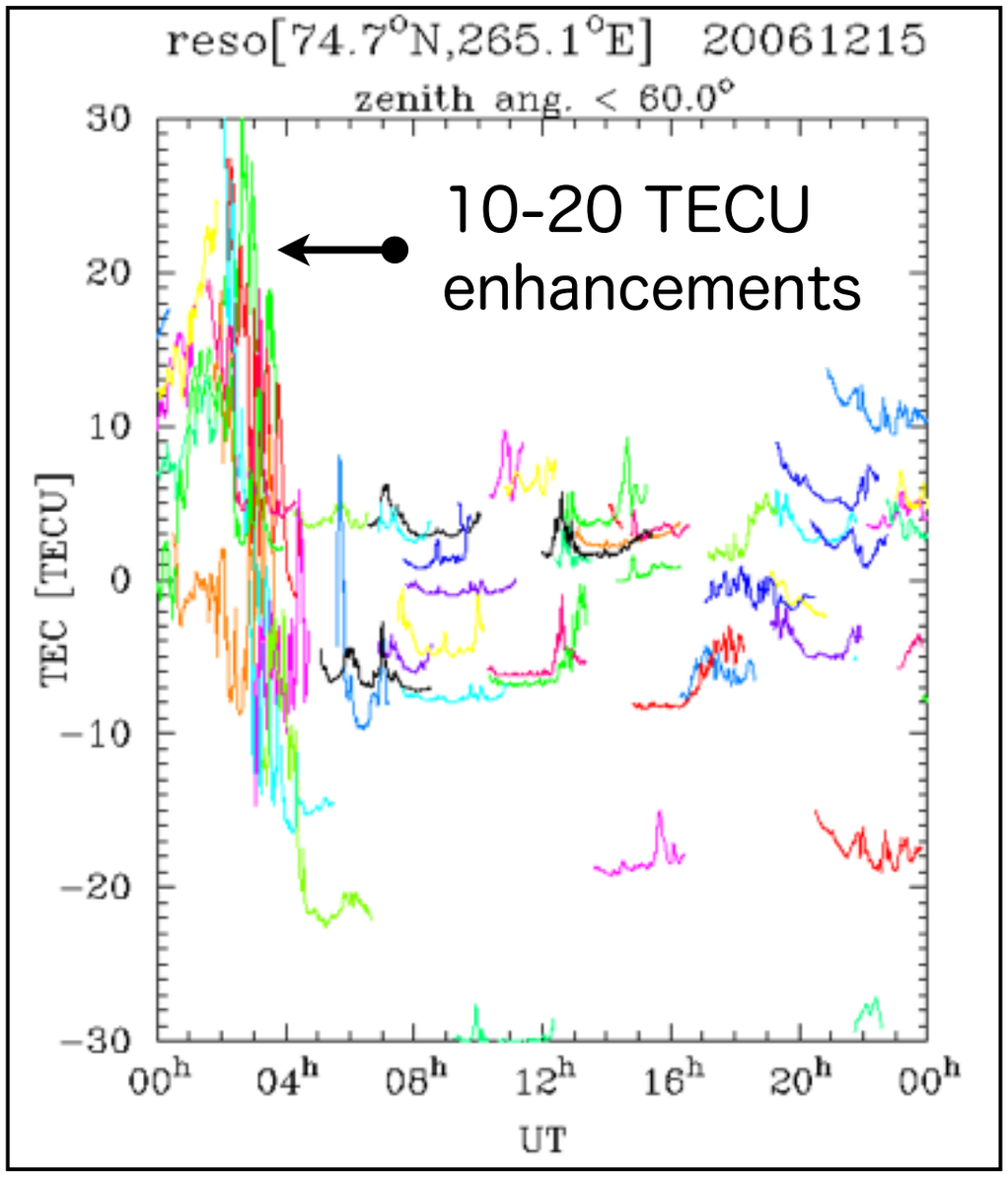


December 15, 2006

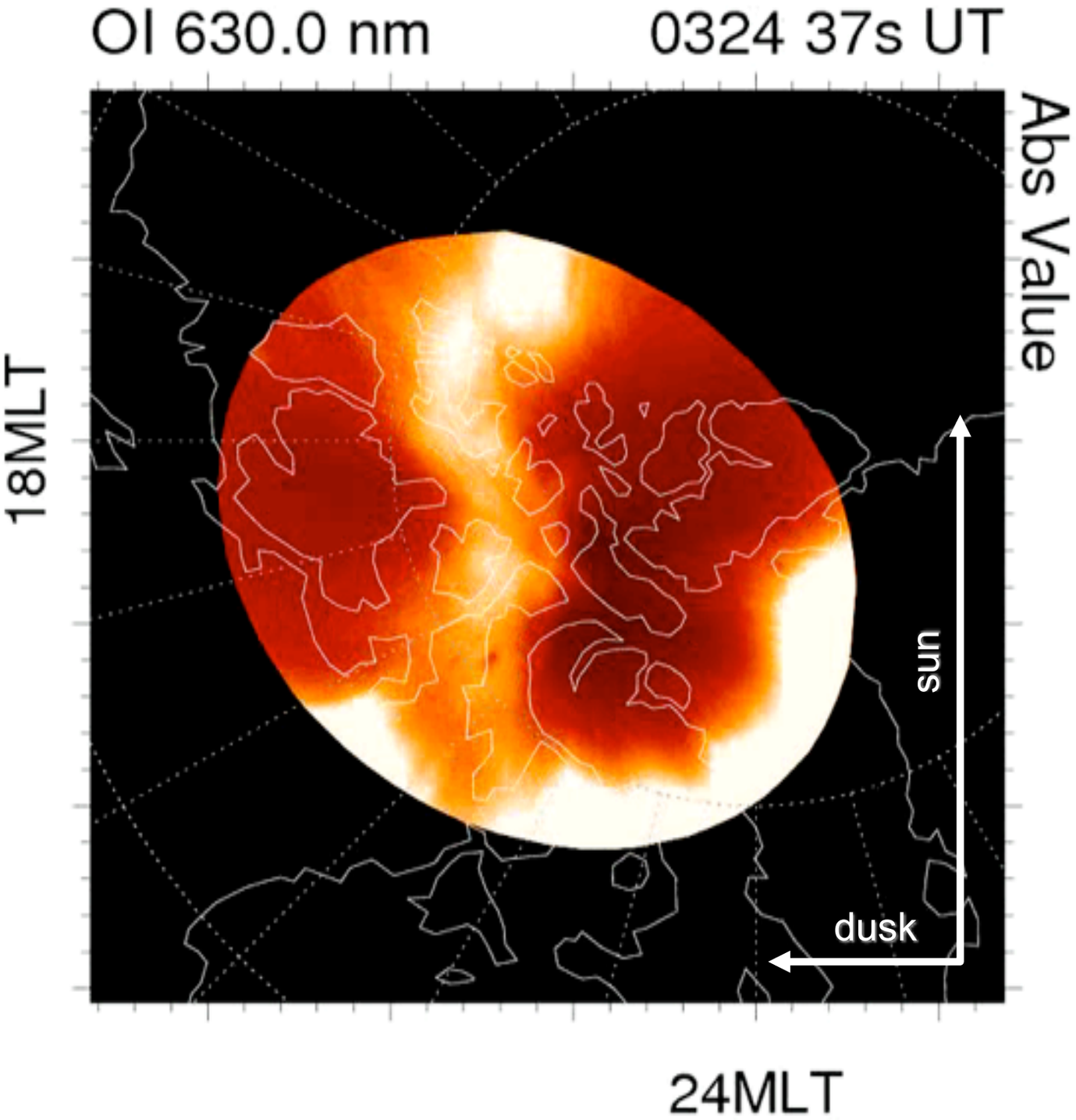
Dense plasma stream in the polar cap



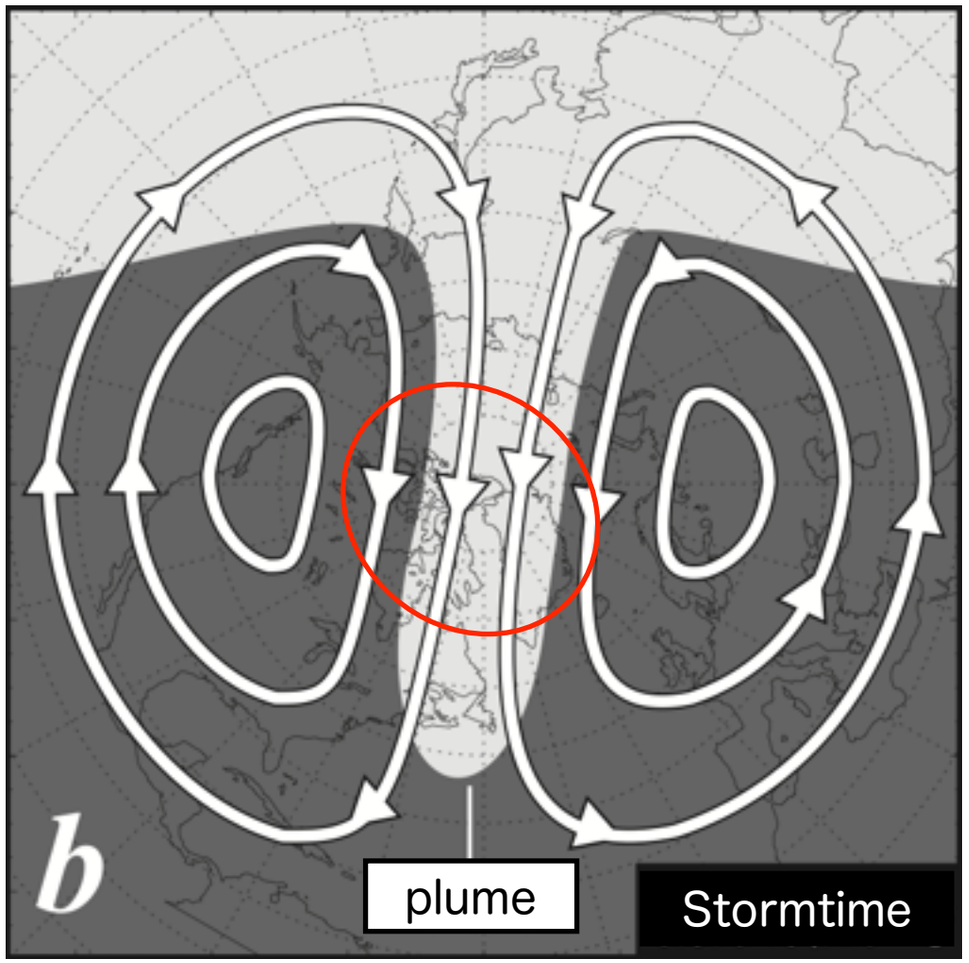
TEC data from Resolute Bay



Dense plasma stream in the polar cap



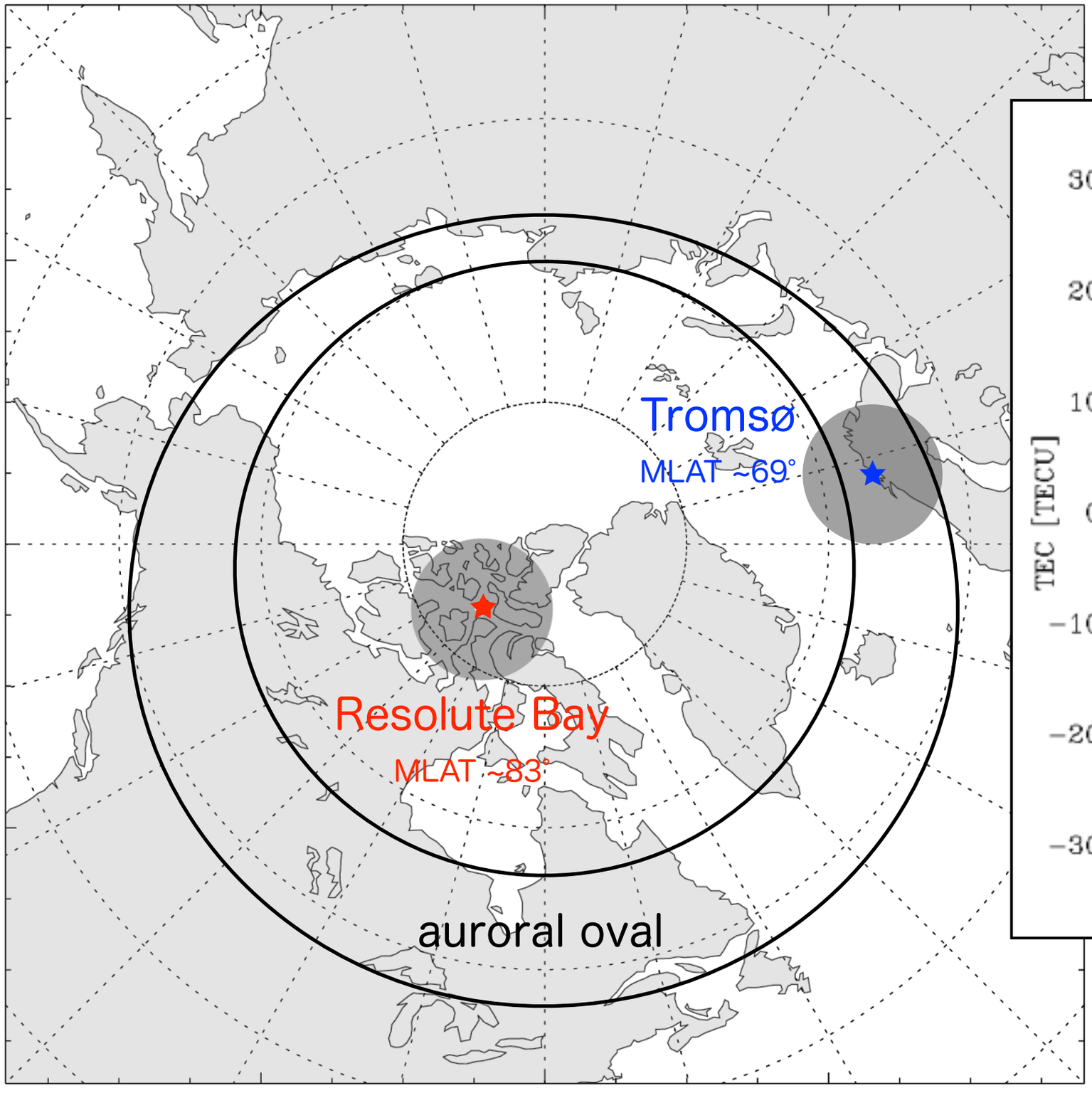
Dayside high density plasma



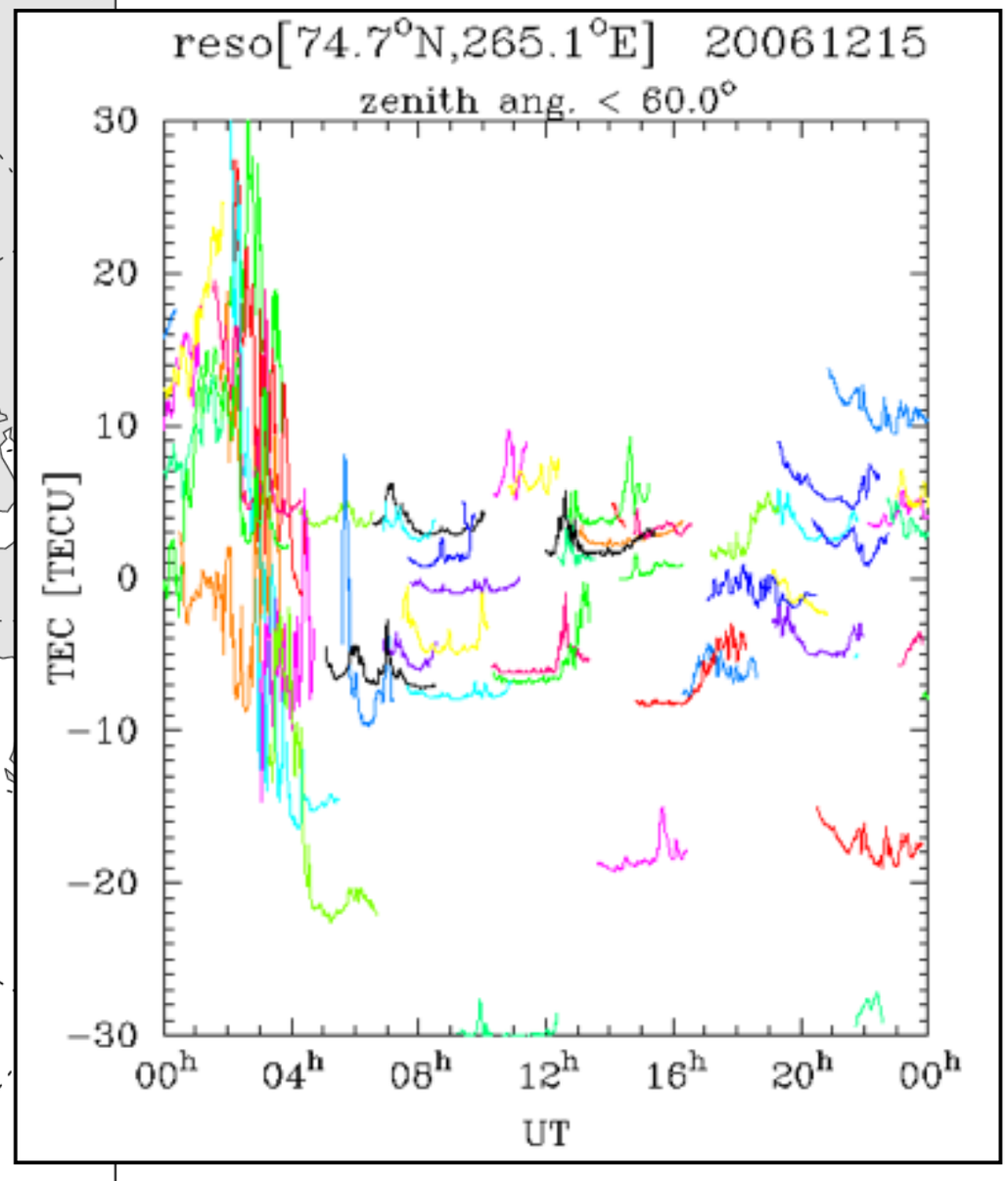
Nightside low density plasma

Hosokawa et al., 2009, 2010

Optical observations in the polar region

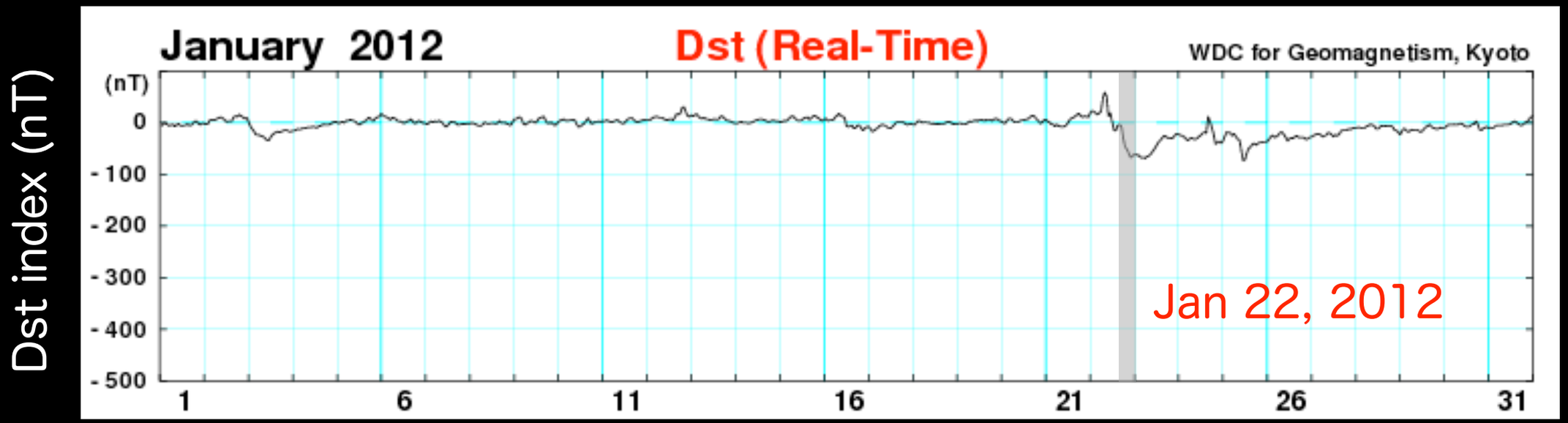


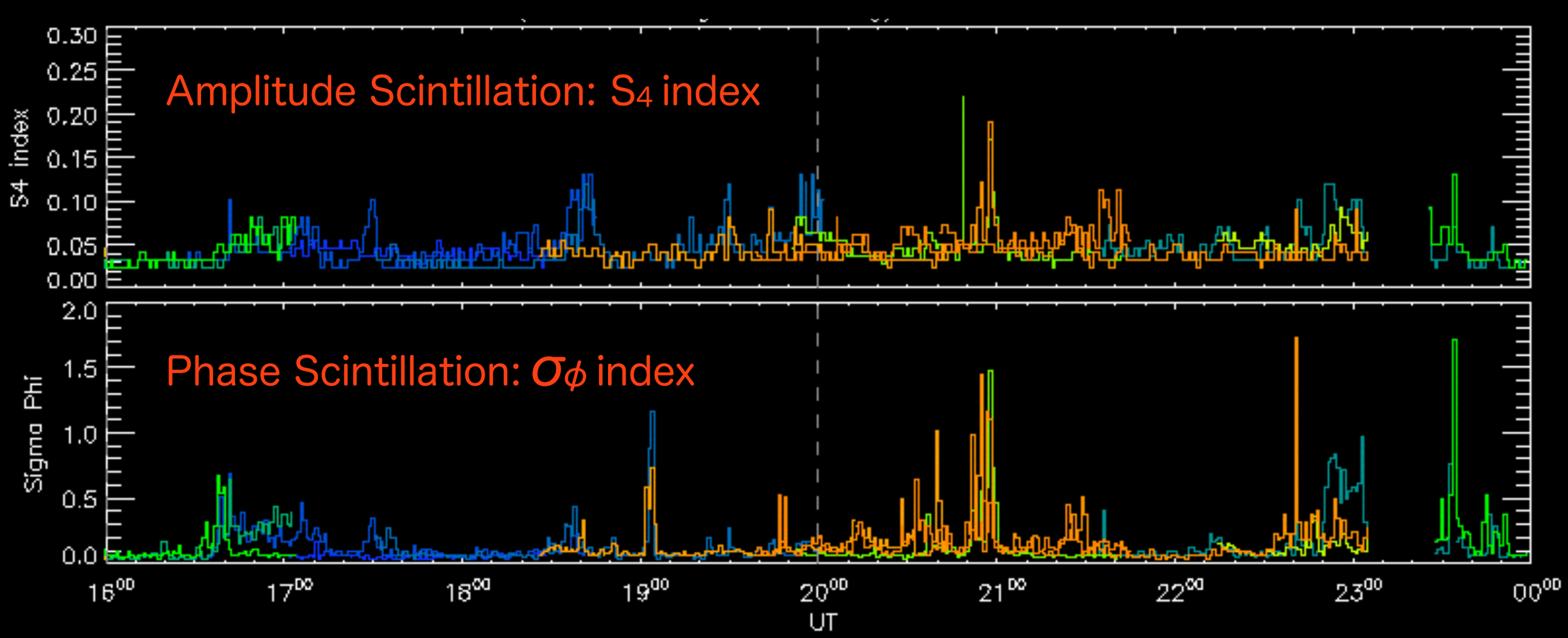
10-20 TECU enhancements



TEC data from Resolute Bay

Scintillation in the auroral region

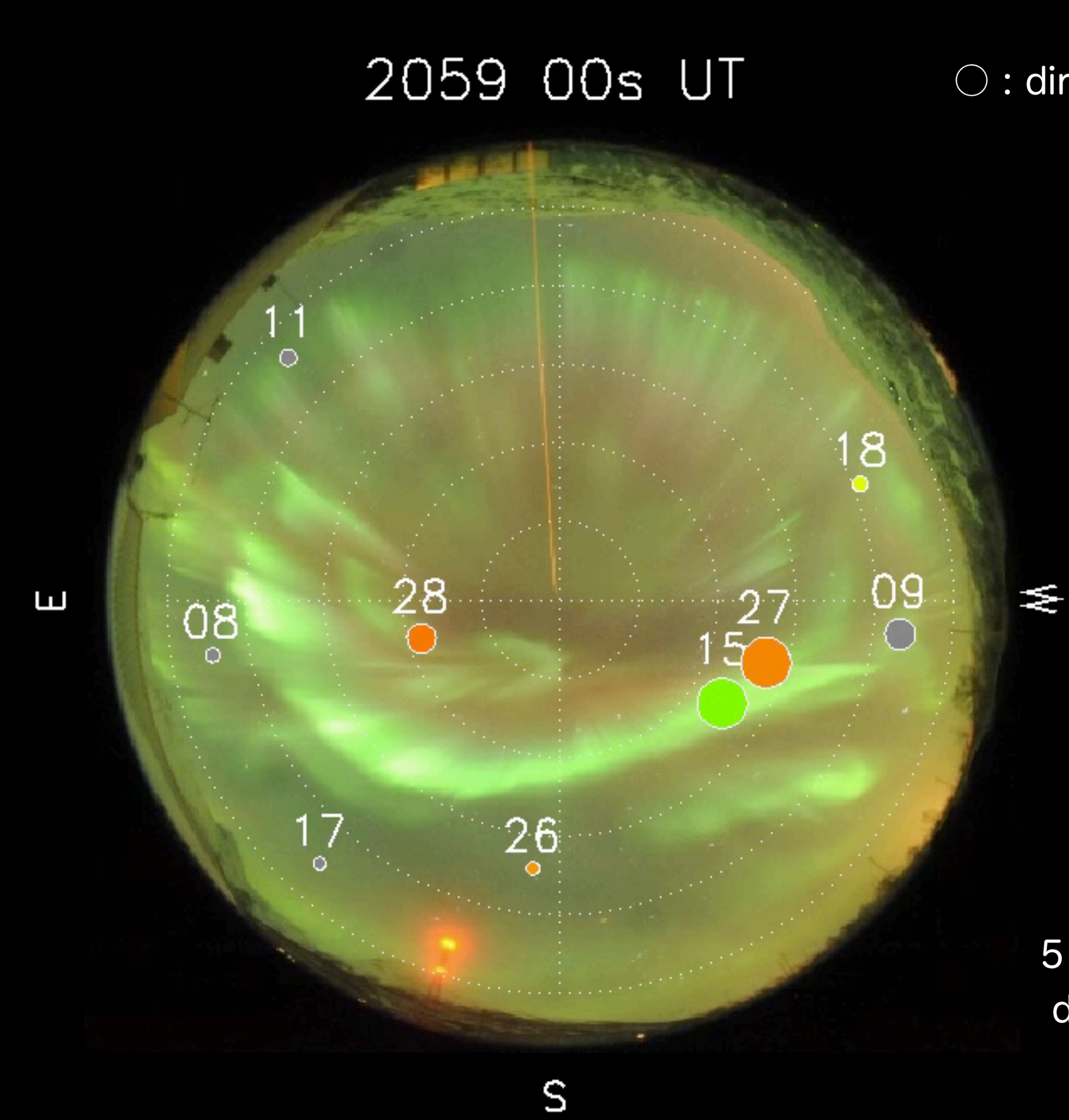




2059 00s UT

○ : direction of GPS satellites

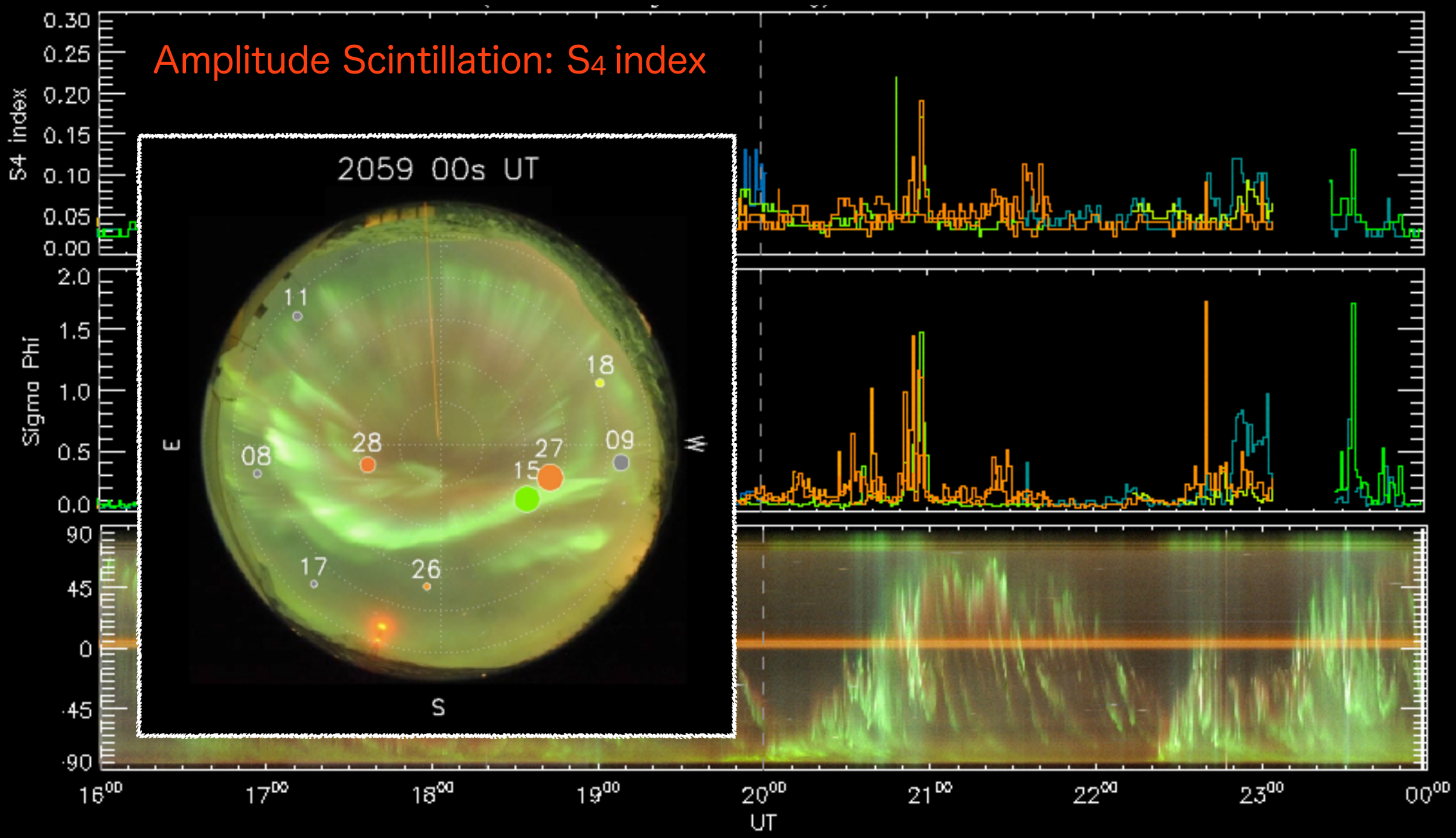
The size of ○ indicates
the magnitude of σ_ϕ



5 hours of all-sky images
during a magnetic storm
on January 22, 2012

Ionospheric scintillation vs aurora display

Almost one-to-one correspondence between scintillations and auroral appearance



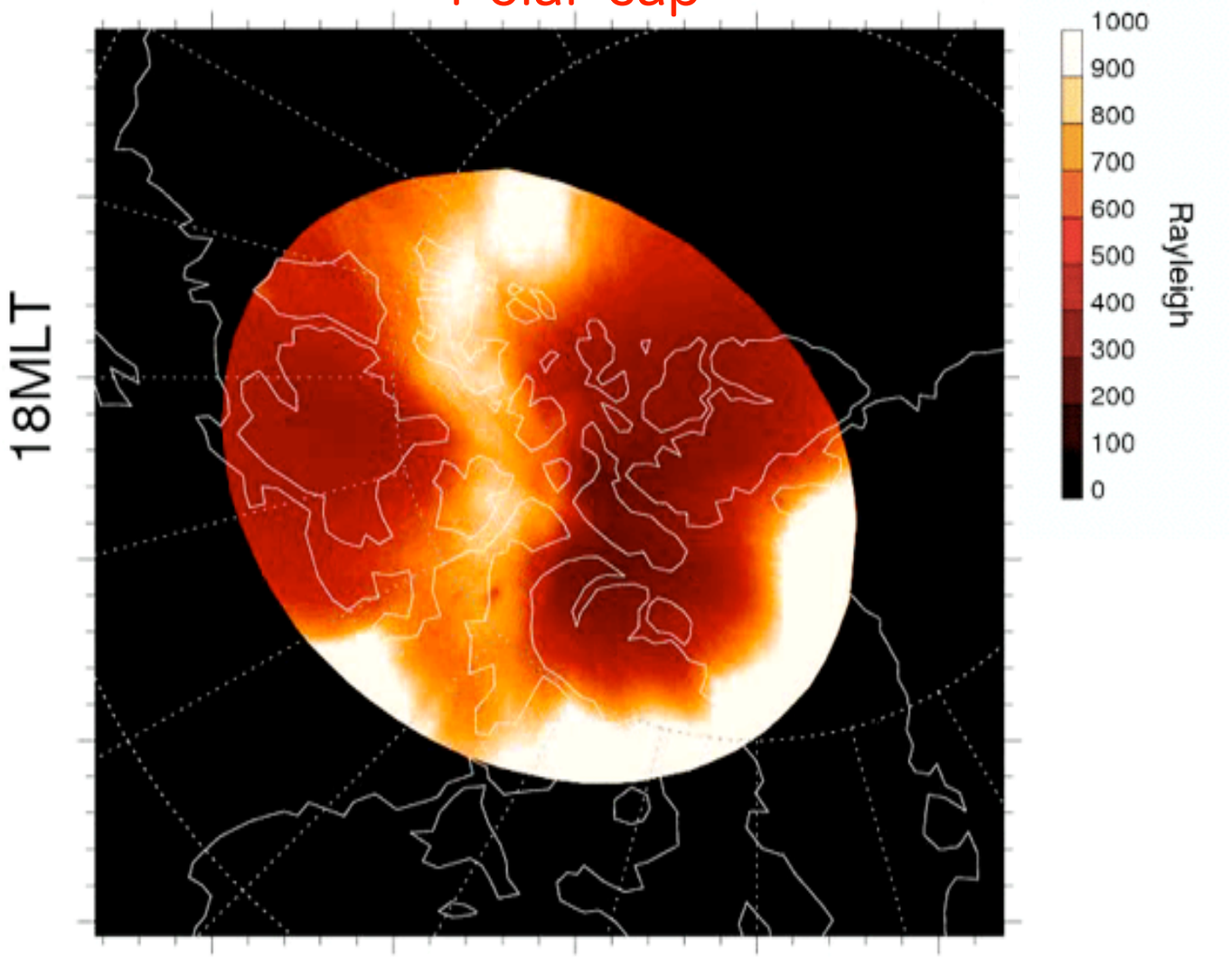
Summary

Space weather impacts of the ionosphere on the GNSS systems during storms:

1. Polar cap region: dense plasma plume induces positioning errors
2. Auroral region: aurora causes scintillation of the navigation signals

Ground-based optical instruments help us to better understand these impacts.

Polar cap



Auroral region