Monitoring the Auroral Oval with GPS and Applications to WAAS

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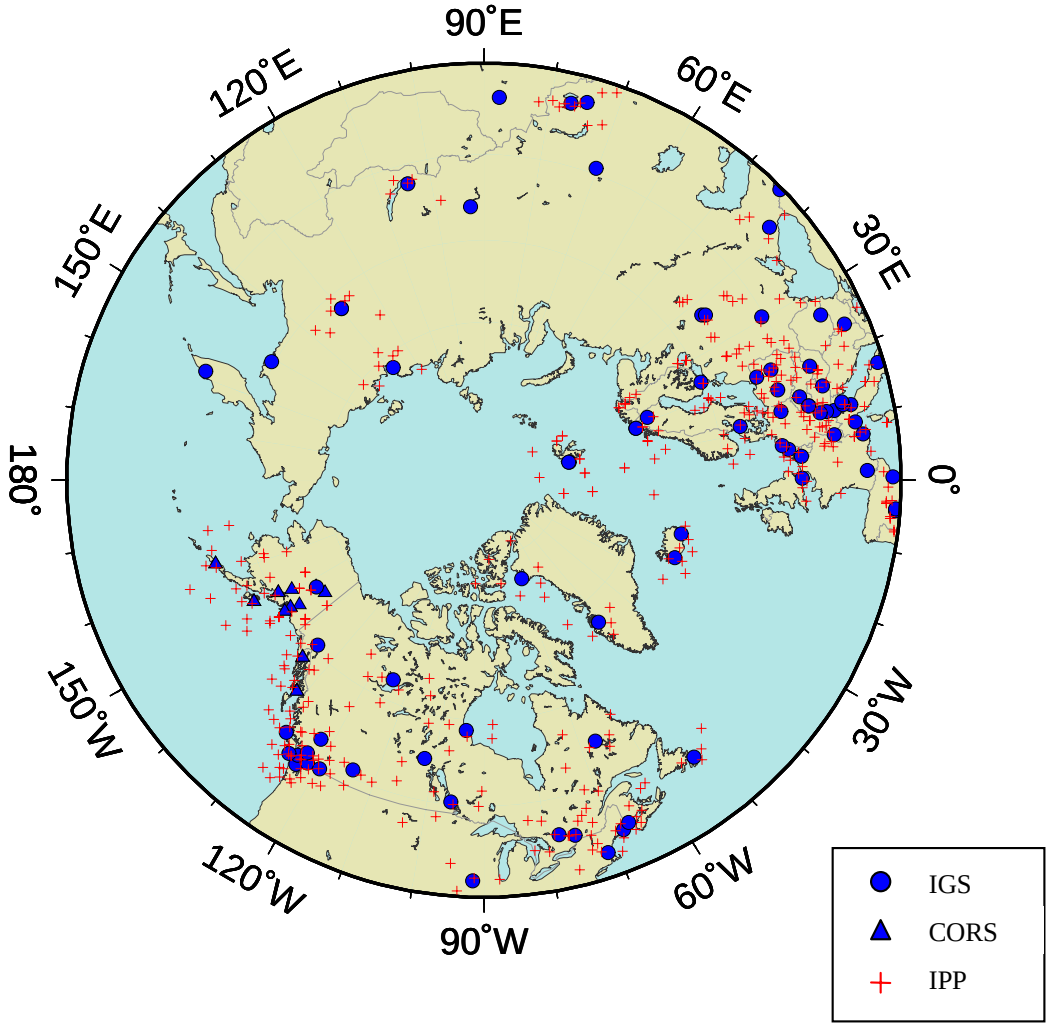
Introduction

- Large spatial and temporal gradients are often found in the auroral ionosphere.
- Any attempt to model and mitigate for ionospheric effects in the auroral zone (e.g.WAAS) must take these variations into account
- Monitoring of the rate of change of ionospheric delay measured at a network of dual frequency GPS receivers is proposed as a method of monitoring the location of the auroral oval.

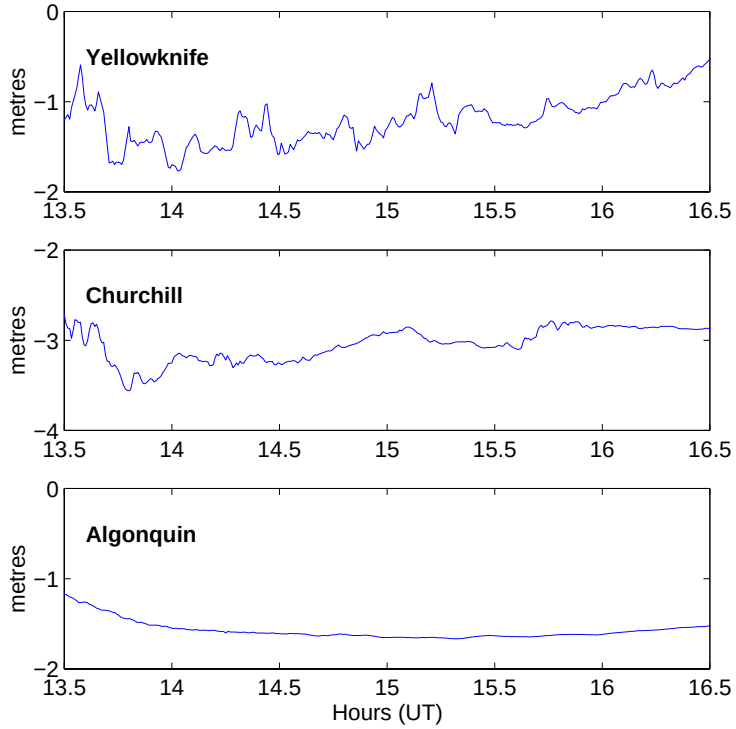
IGS and CORS Stations

- International GPS Service (IGS) and Continuously Operating Reference System (CORS) dual frequency GPS data available freely over the internet
- Data distribution is limited by the locations of these receivers, and there are still large “holes” in coverage



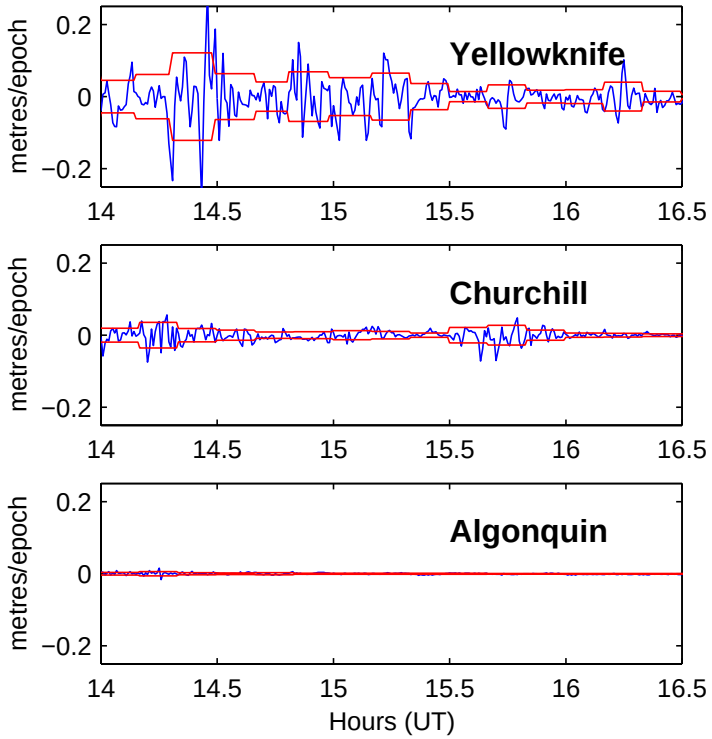
Variation of Ionospheric Delay from dual frequency phase observations

- Differencing the L1 and L2 phase observations provides a precise but ambiguous measure of ionospheric delay.
- Assuming that no cycles slips occur, the ambiguity is removed, and an accurate measure of the rate of change of ionospheric delay can be obtained.
- Large variations in ionospheric delay indicate large spatial and temporal gradients
- Large spatial and temporal gradients suggest that the satellite to receiver line of sight is passing through the auroral oval



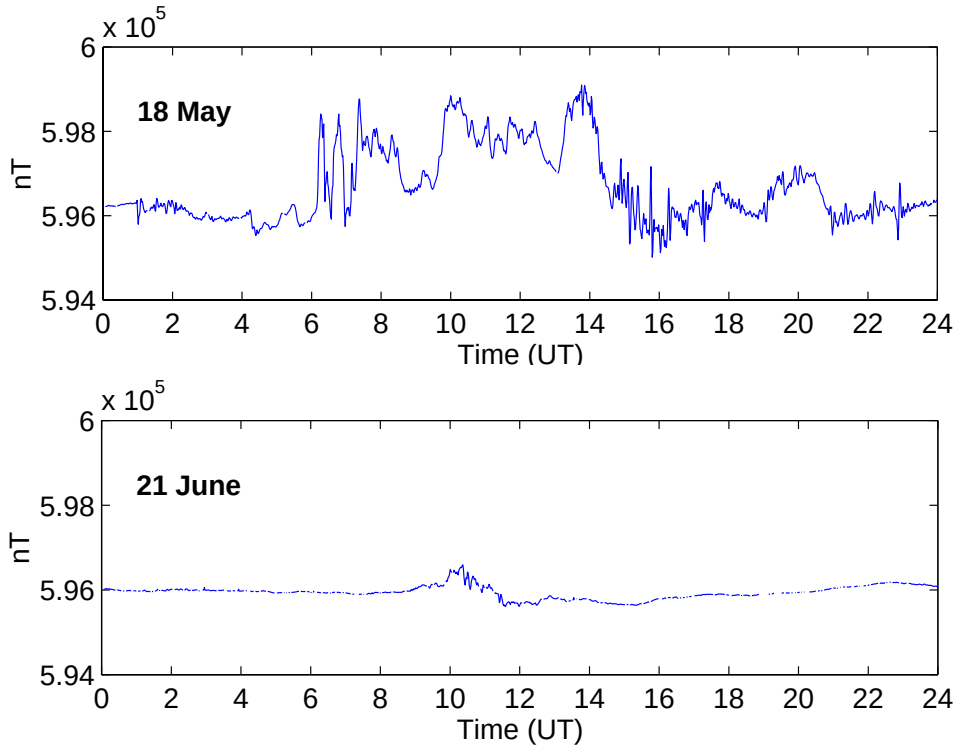
Rate of change of ionospheric delay

- Differencing successive epochs removes the influence of the unknown ambiguity and the inter-frequency biases
- Data binned into ten minute sections
- Standard deviation taken in each bin
- This parameter is then used as the input to surface fit routine, from which maps of the auroral zone are created

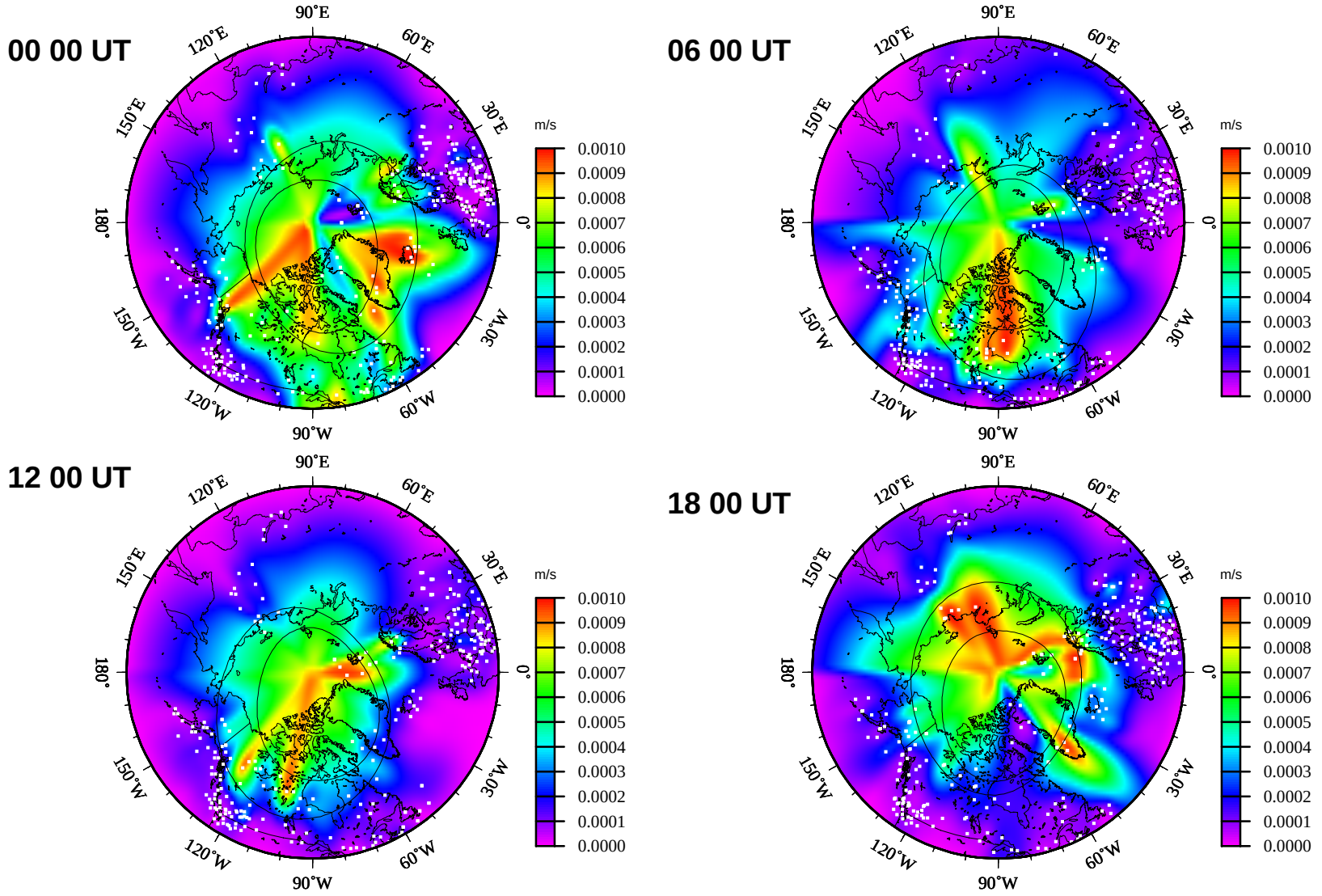


Geomagnetic field variation as an indicator of auroral activity

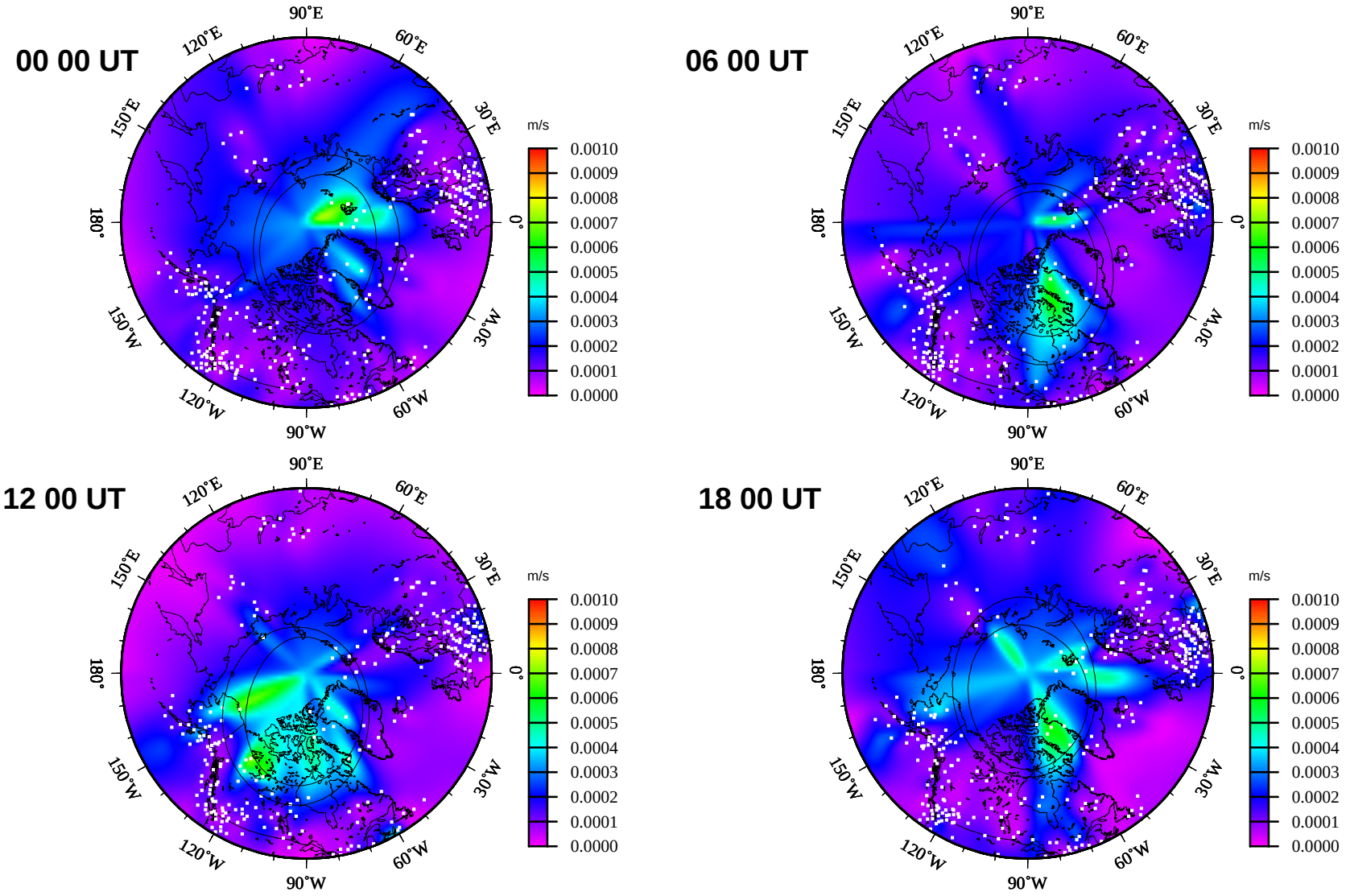
- Fluctuations in the local geomagnetic field occur as a result of enhanced electric currents flowing in the auroral ionization.
- Heightened geomagnetic variability can therefore be seen as a reliable indicator of increased auroral activity.



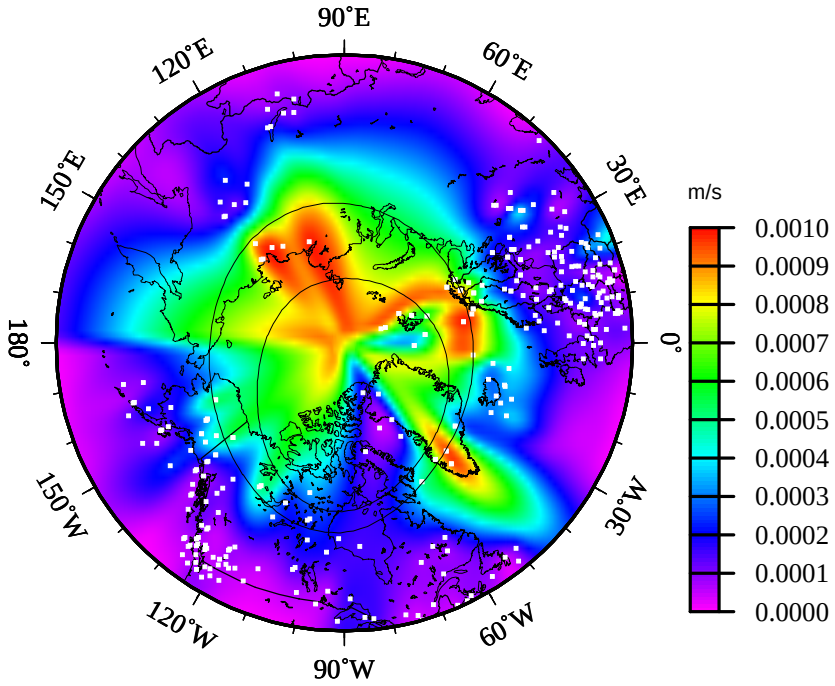
Location of auroral oval from GPS observations: 18 May 1999



Location of auroral oval from GPS observations: 21June 1999



Comparison with NOAA Statistical Auroral Oval



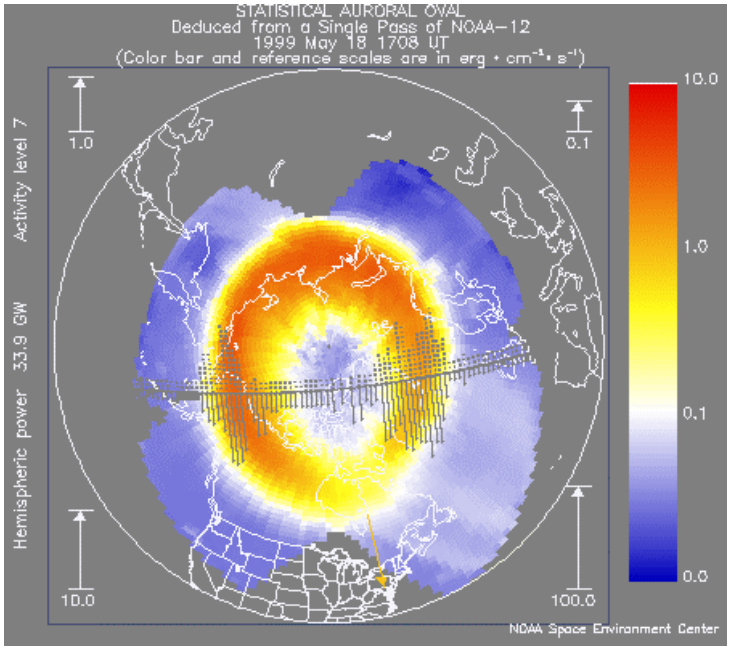
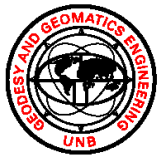


Image provided courtesy of the U.S. Department of Commerce, NOAA, Space Environment Center.



Summary and Conclusions

- Monitoring the rate of change of ionospheric delay with GPS shows promise as a method of locating the auroral oval
- Large spatial and temporal gradients in the auroral ionosphere can have an effect on GPS and WAAS in two ways:
  - any grid model is unlikely to have high enough spatial resolution to adequately represent an active auroral zone
  - scintillation activity in the auroral zone is a potential problem, and has been shown to cause losses of lock of the L2 signal
- It is therefore important to understand the spatial extent of areas which are likely to have an effect on GPS
- Due to the higher inclination of satellites, GLONASS data could be used to augment any GPS based monitoring of the auroral zone.