



Ionospheric Modelling for WADGPS at Northern Latitudes

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Introduction



- Objective - to investigate the suitability of the currently proposed WAAS ionospheric modelling scheme for use in Canadian airspace
 - Work sponsored by Nav Canada
- Research objectives
 - Assess the WAAS ionospheric grid model for Canadian operational use over the full range of solar activity intensities
 - Identify “interesting” periods of ionospheric activity in historical data and assess the associated performance of the WAAS model
 - derivation of some *ad hoc* indicator of geomagnetic activity [cf. Skone and Cannon, 1997]
 - Recommend possible densification of permanent GPS tracking sites in Canada
 - Recommend any improvements needed to the WAAS ionospheric modelling technique



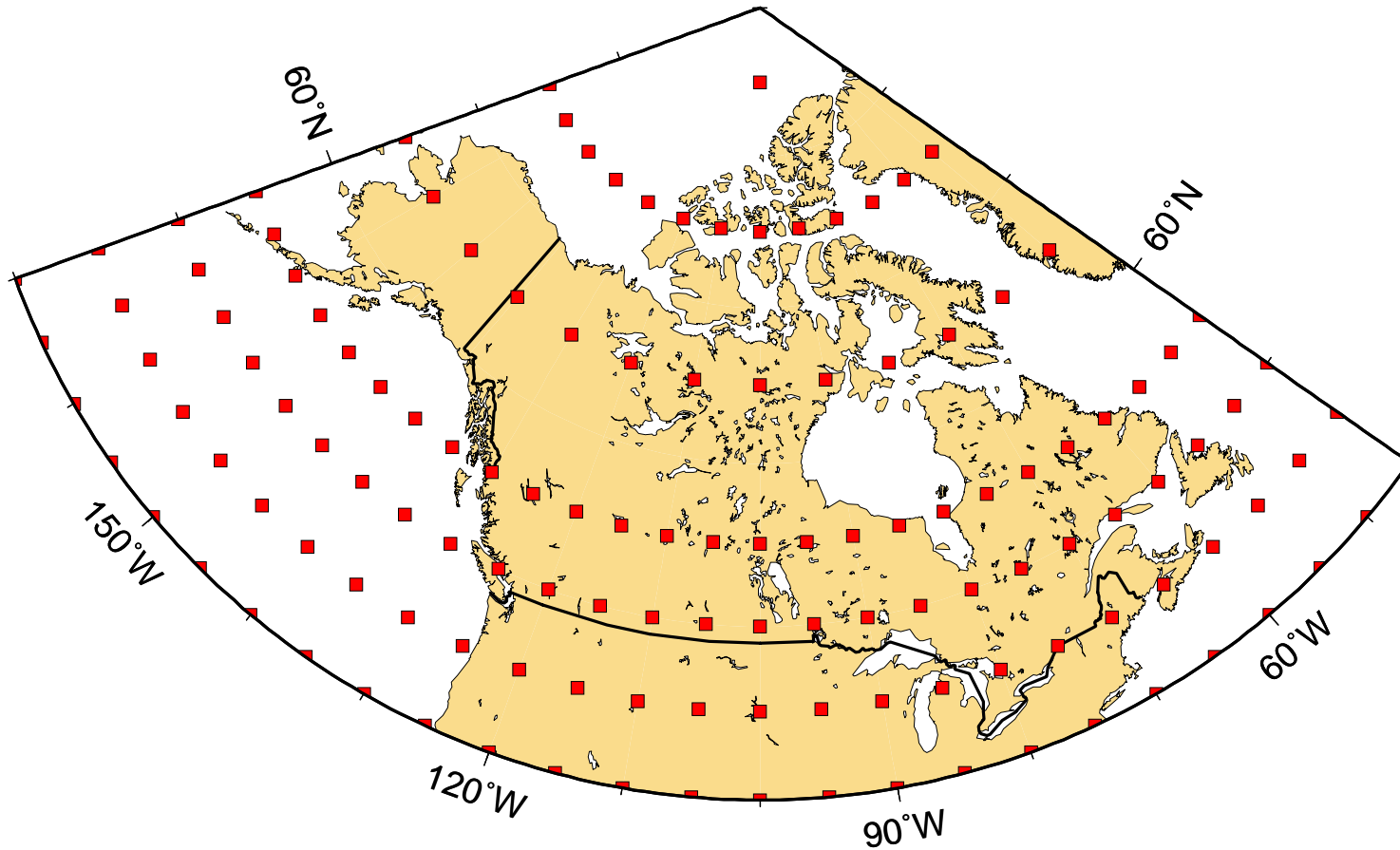
Ionospheric delay mitigation techniques in WAAS



- Network of continuously operating reference receivers provides dual frequency carrier phase and pseudorange measurements
- Line of sight ionospheric delay values estimated from each receiver to each satellite
- Vertical ionospheric delay values at each of a series of ionospheric grid points (IGPs) are estimated along with an error bounding value (GIVE)
- Corrections to user line of sight delays, and a user error bounding value can then be created



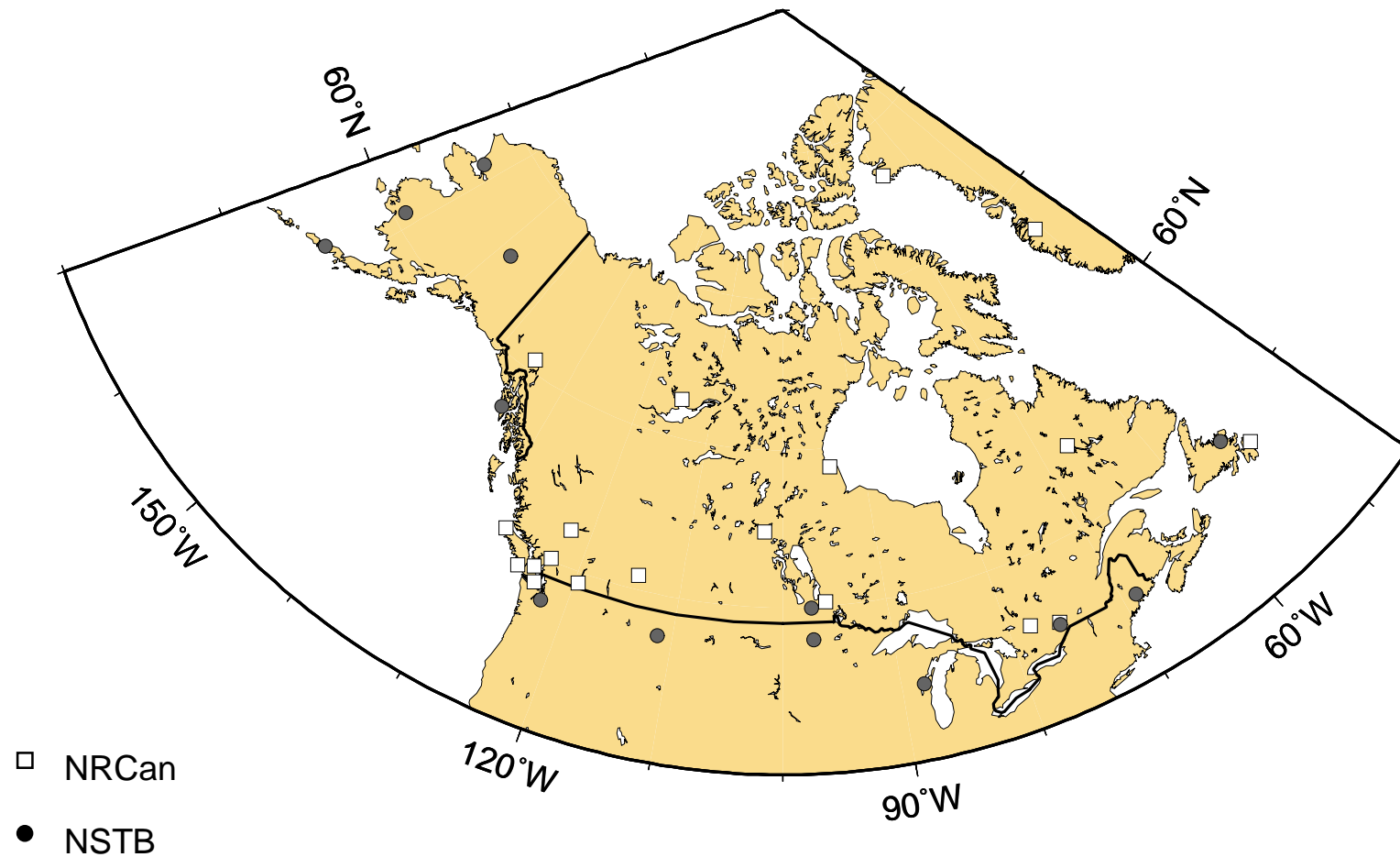
IGPs in Canadian airspace



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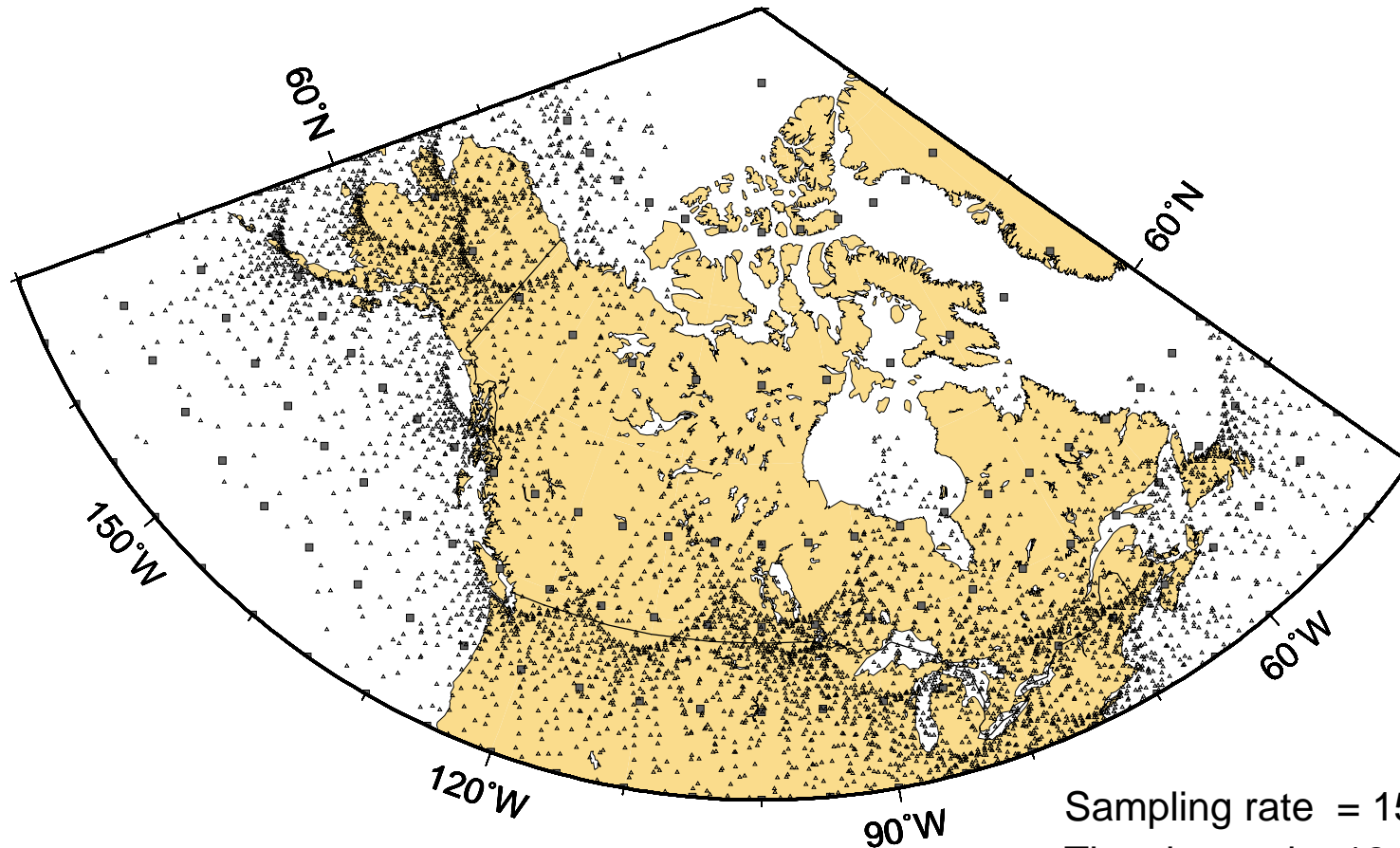
NSTB and NRCan Station Locations



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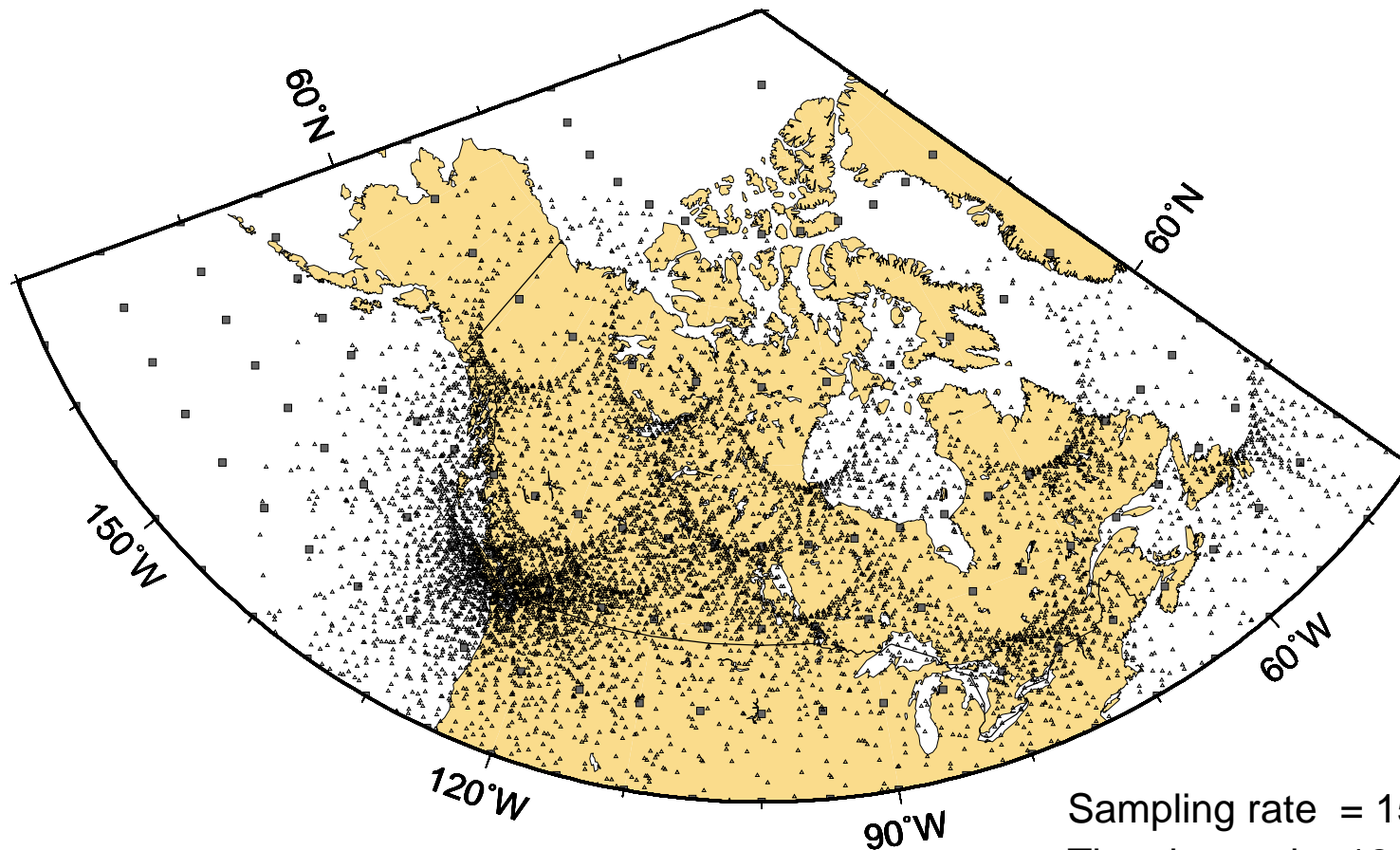
IPPs from current NSTB stations



Sampling rate = 15 minutes
Time interval = 12 hours
Elevation cut off = 5°



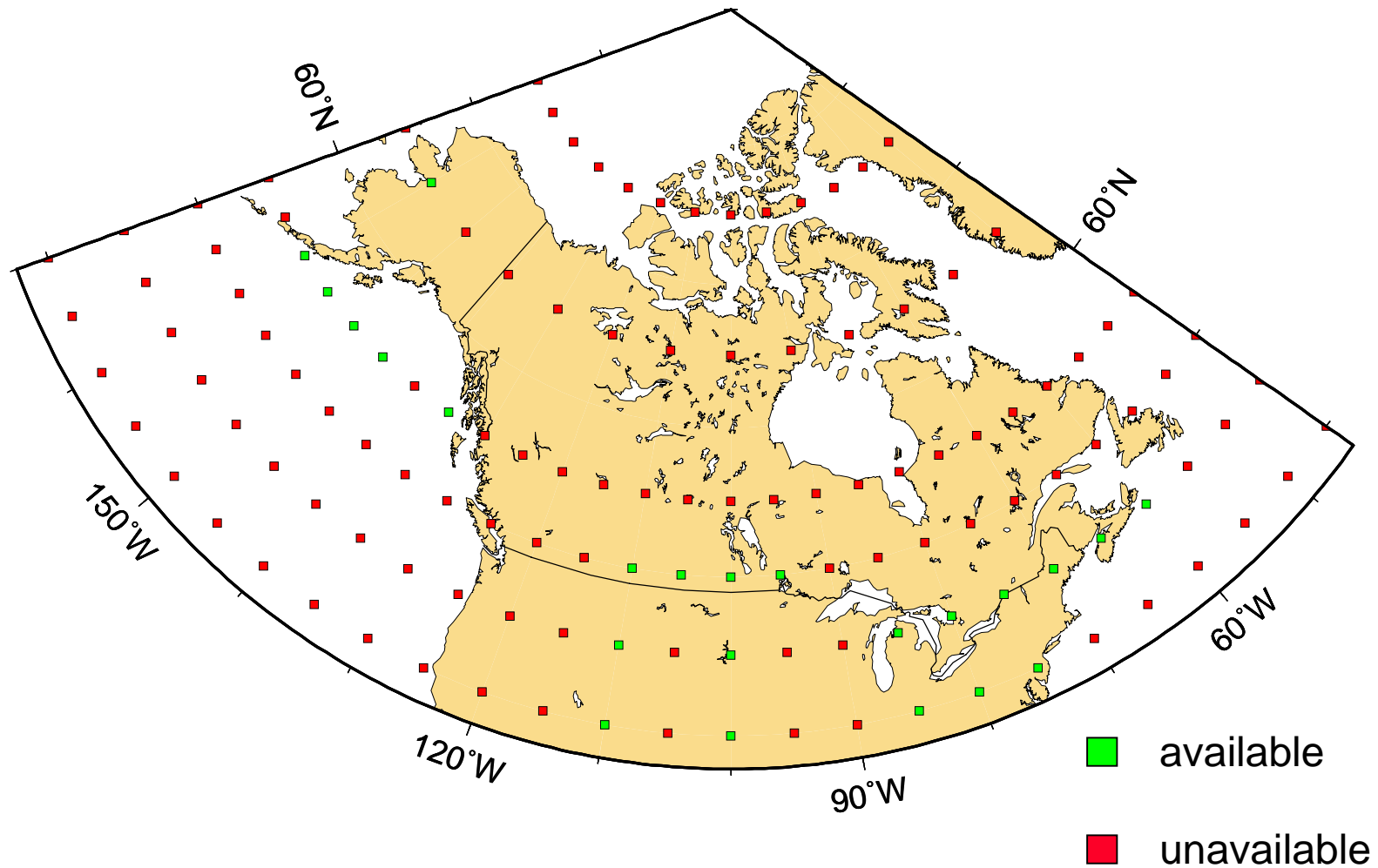
IPPs from NRCan stations



Sampling rate = 15 minutes
Time interval = 12 hours
Elevation cut off = 5°

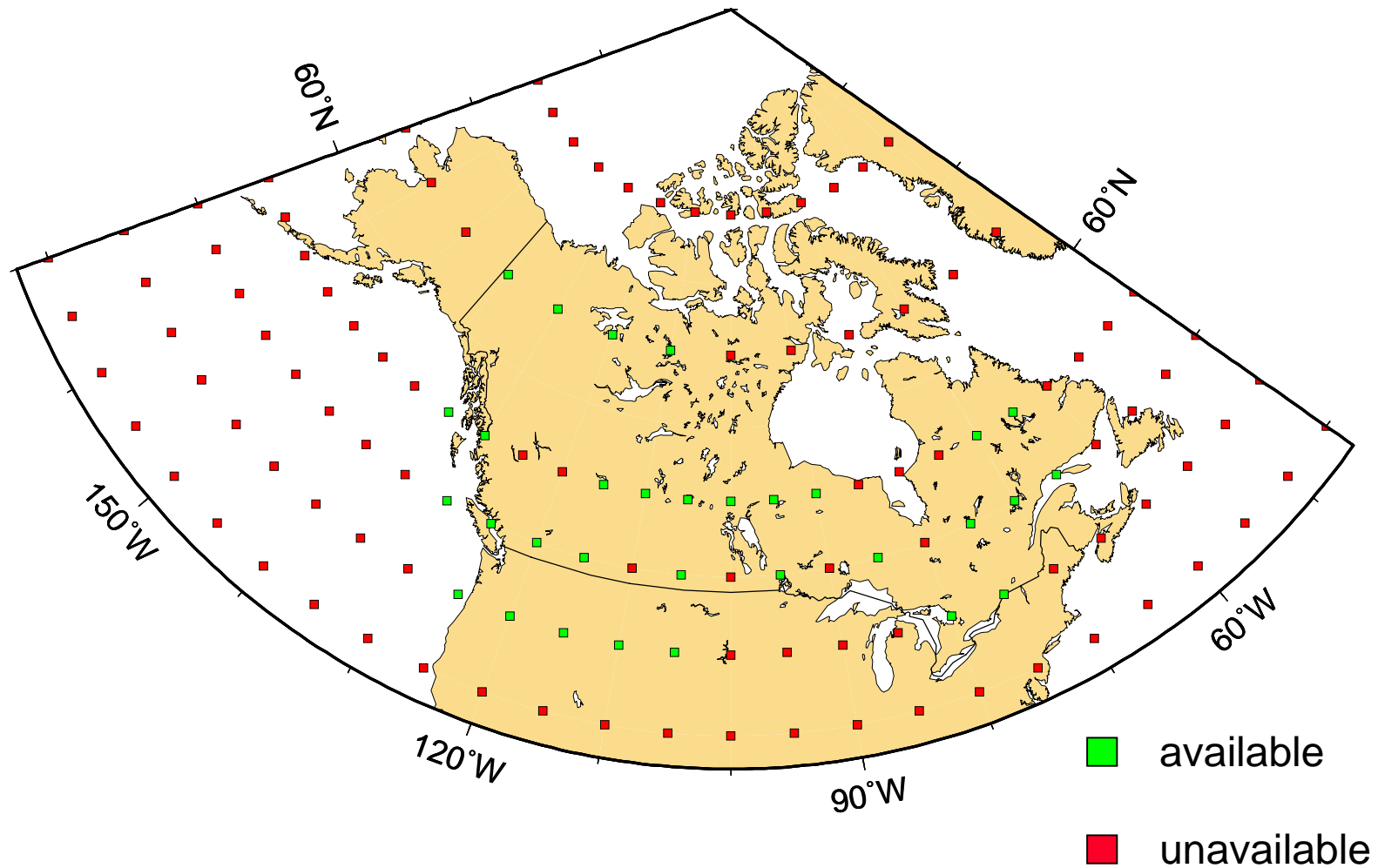


IGP Availability in Canada using NSTB sites



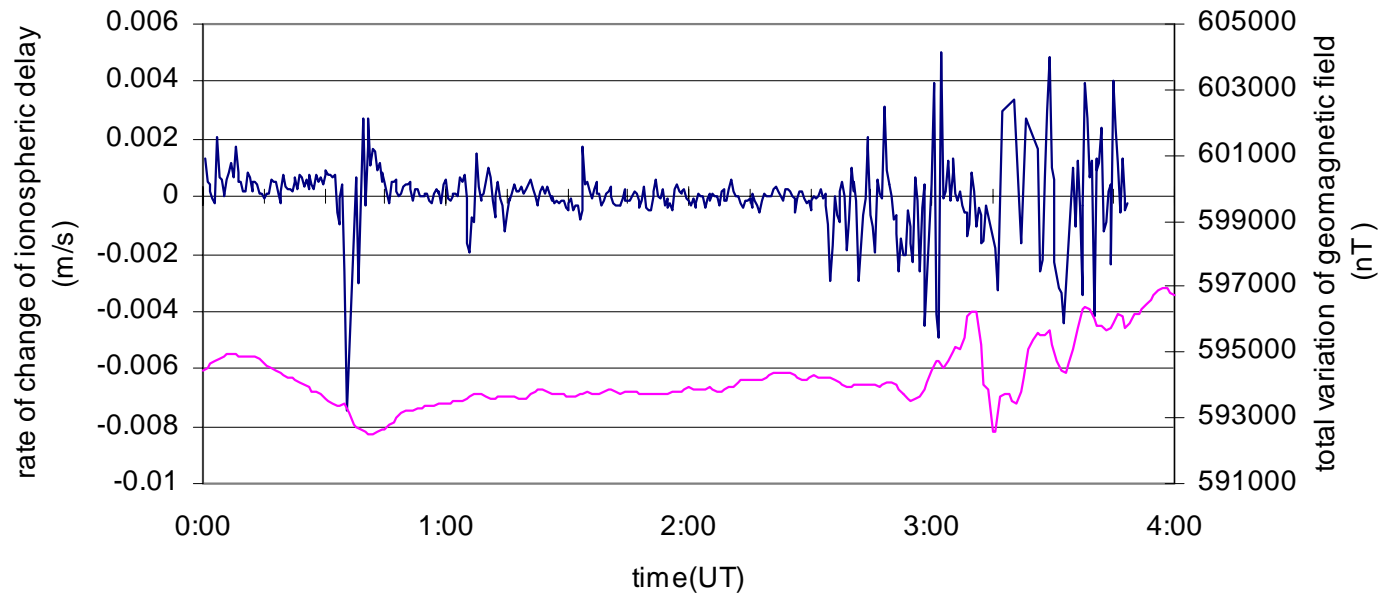


IGP availability in Canada using Canadian IGS sites





Correlation with Geomagnetic field variation

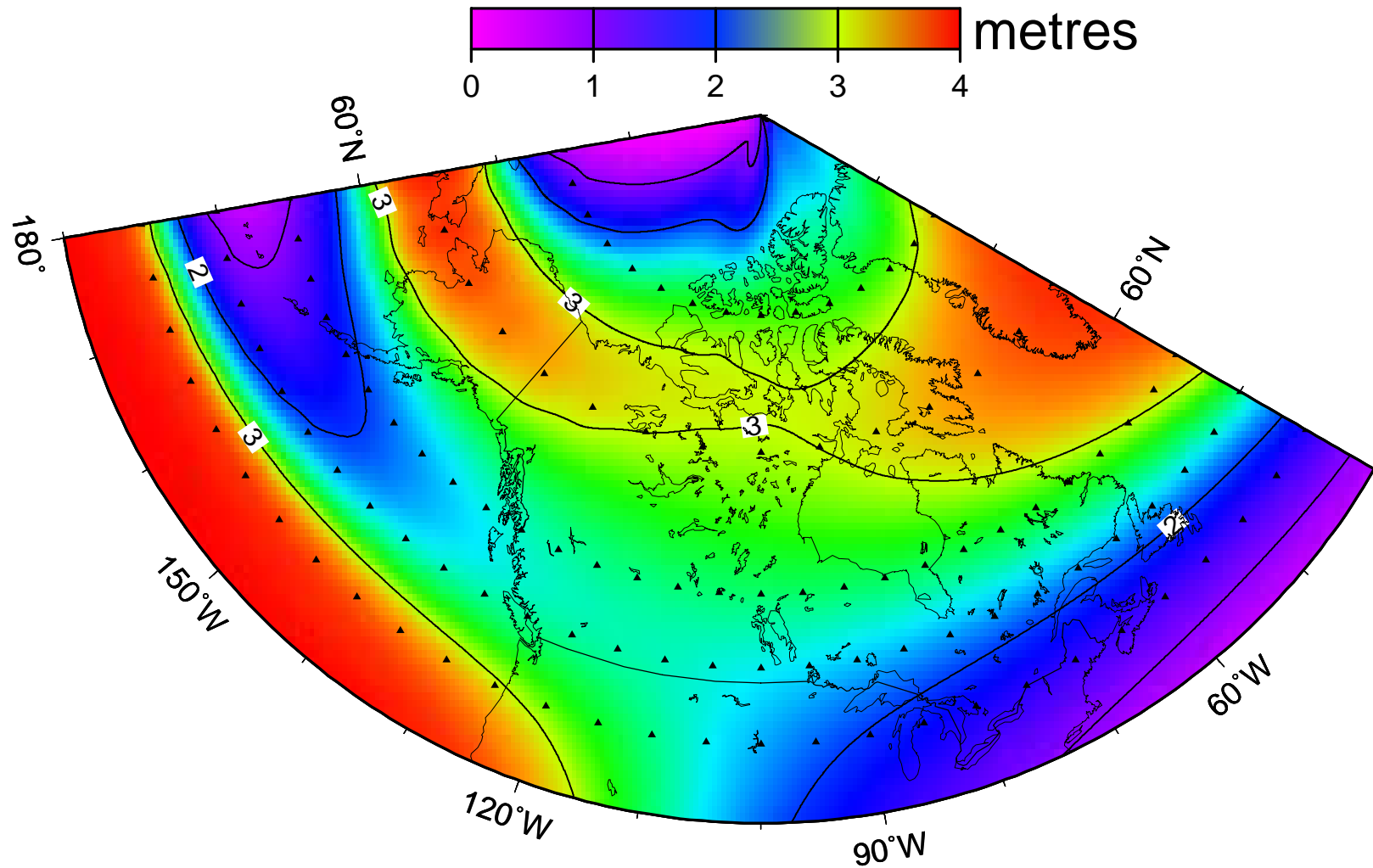


Rate of change of ionospheric delay plotted with total Geomagnetic field variation, 4 May, 1998.

Note that the TurboRogue receiver located at Yellowknife continued to track through this period of significantly enhanced geomagnetic activity ($K_p = 9_0$).



Interpolated Ionospheric Delay Surface





Issues



- Potential ionospheric limitations on WAAS use over the Canadian landmass
- Ability of currently proposed grid structure to adequately model large scale gradients in the auroral and polar cap ionosphere
- Magnitude and frequency of occurrence of “significant” scintillations in the auroral and sub-auroral zone
 - identification of potentially problematic periods for tracking of GPS and/or WAAS signals
 - prediction of effects of increasing solar activity



Summary and Future Work



- Implementation of WAAS in Canada requires careful consideration of ionospheric effects
- Validation of WAAS ionospheric grid model a primary task
- Outline system and methodology to monitor operational WAAS/CWAAS ionospheric modelling performance
- Contingency plan if current WAAS model proves to be insufficient