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P2.21: A CASE STUDY OF THE 2001/2002 WINTER POLAR ARCTIC STRATOSPHERE AS INFERRED FROM GPS RADIO OCCULTATIONS.

by

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6th Nov 2002

Abstract: GPS radio occultations captured by receivers on board the CHAMP and SAC-C spacecraft were used to study the evolution of temperature profiles in the Arctic region north of 65 degrees. The measurements captured the evolution of the coldest point in the lowest stratosphere, the thermal structure of the lower stratosphere, and the evolution of the lapse rate tropopause. Also the high resolution of the observations enabled to identify conditions for the potential formation of polar stratospheric clouds at locations and times that were overseen by the NCEP analysis. Implications for the dynamics of the chemistry at the lower polar stratosphere may be significant.

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Introduction:

Motivation The stratospheric regions bounded by the polar jet set the stage where several climate phenomena occur. Ozone depletion, and the arctic oscillation being possibly the most popular. Characterization of the thermodynamical conditions in which these processes take place help to improve our understanding of the evolution and effects of such climate processes.

This region also challenges our notions of tropopause. Unlike the tropics, the coldest temperature is not always reached near the lapse rate tropopause, and a large region is nearly isothermal.

The polar and subpolar tropopause and stratosphere have been object of less studies than the tropical latitudes. Some studies exist which used radiosondes and model reanalyses (e.g. Zängl & Hoinka, J. Climate **14**, 3117, 2001). Radiosondes offer high accuracy and vertical resolution, while models provide global coverage. GPS radio occultations offer a combination of both and a comparison with the models may help evaluate the significance of using occultations.

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Coldest height at the stratosphere and WMO-tropopause height:

The polar tropopause is well characterized by a dynamical criterion: the tropopause is the height at which the potential vorticity crosses a given value. Potential vorticity is proportional to the temperature lapse rate, thus a connection exists between the dynamical and the thermal tropopause. The observations only provide thermodynamical no dynamical information, therefore the lapse rate criterion is followed.

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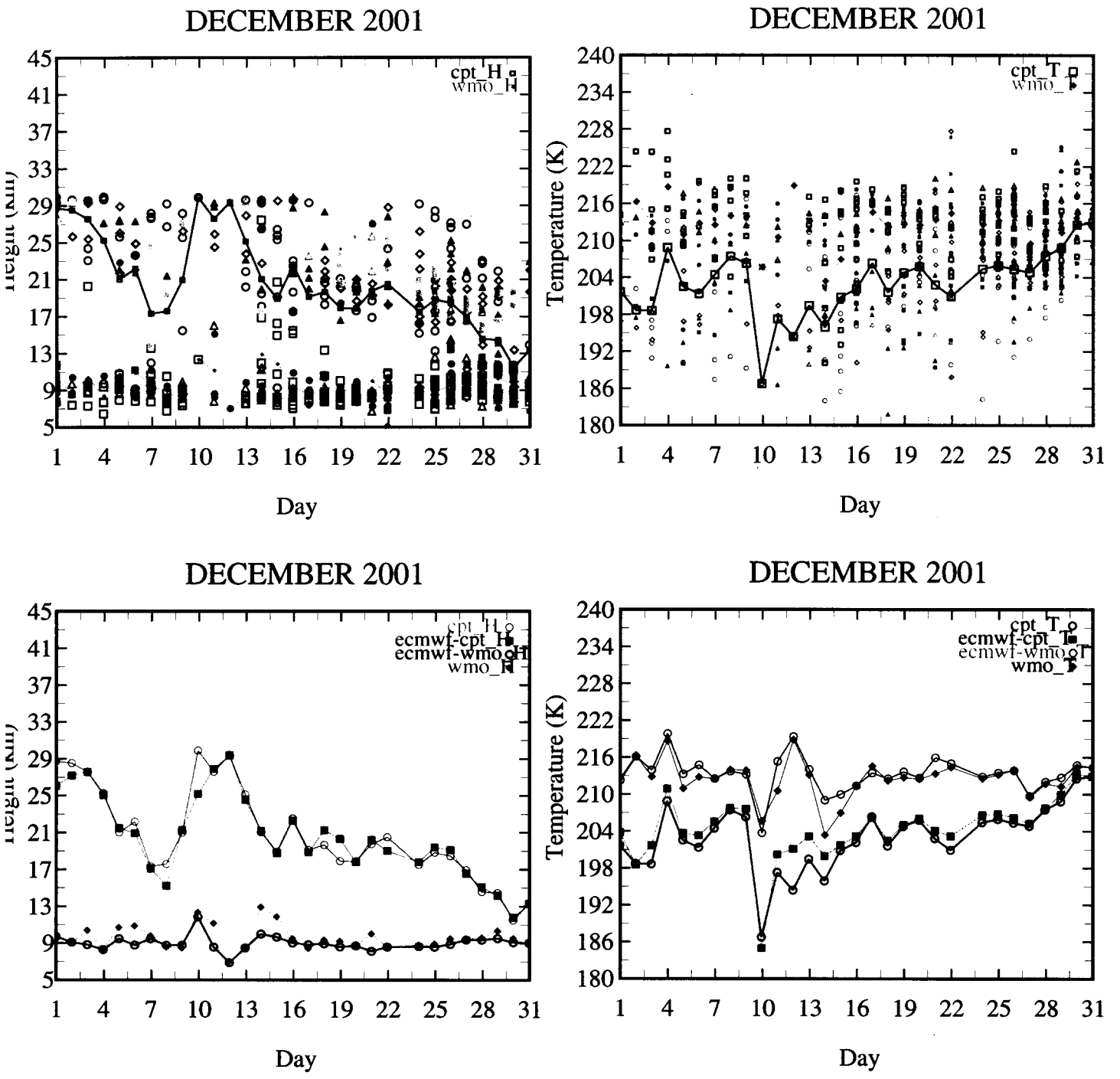
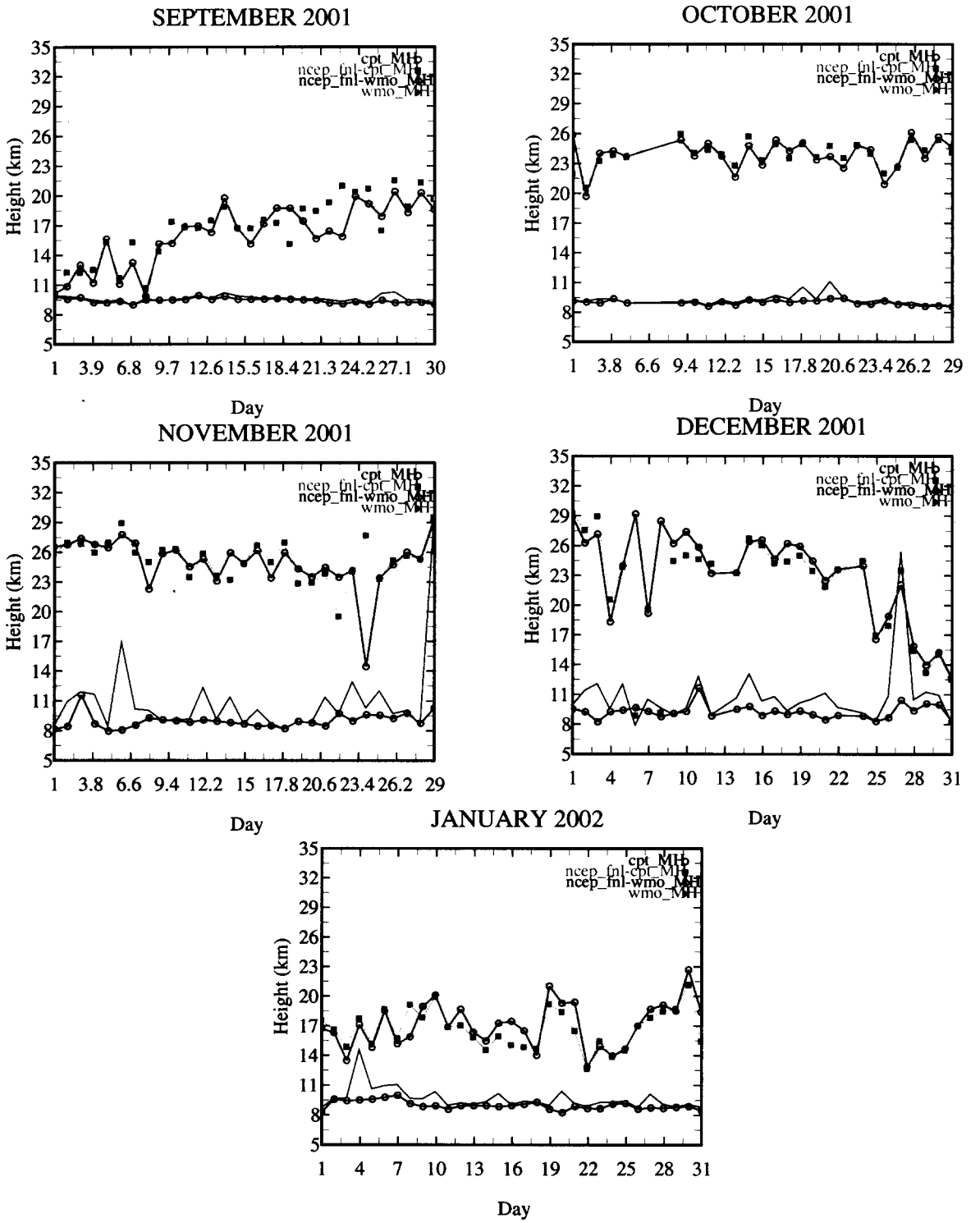


Figure 1: Comparisons between ECMWF and OCCULTATIONS for DECEMBER 2001: heights at which the coldest point in the stratosphere is found, and where the lapse rate meets the WMO definition of the tropopause.



Figures 2: Height of the coldest point and the lapse rate tropopause during the NH Fall according to NCEP and OCCULTATIONS. Both separate in SEPTEMBER, to approach in DECEMBER.

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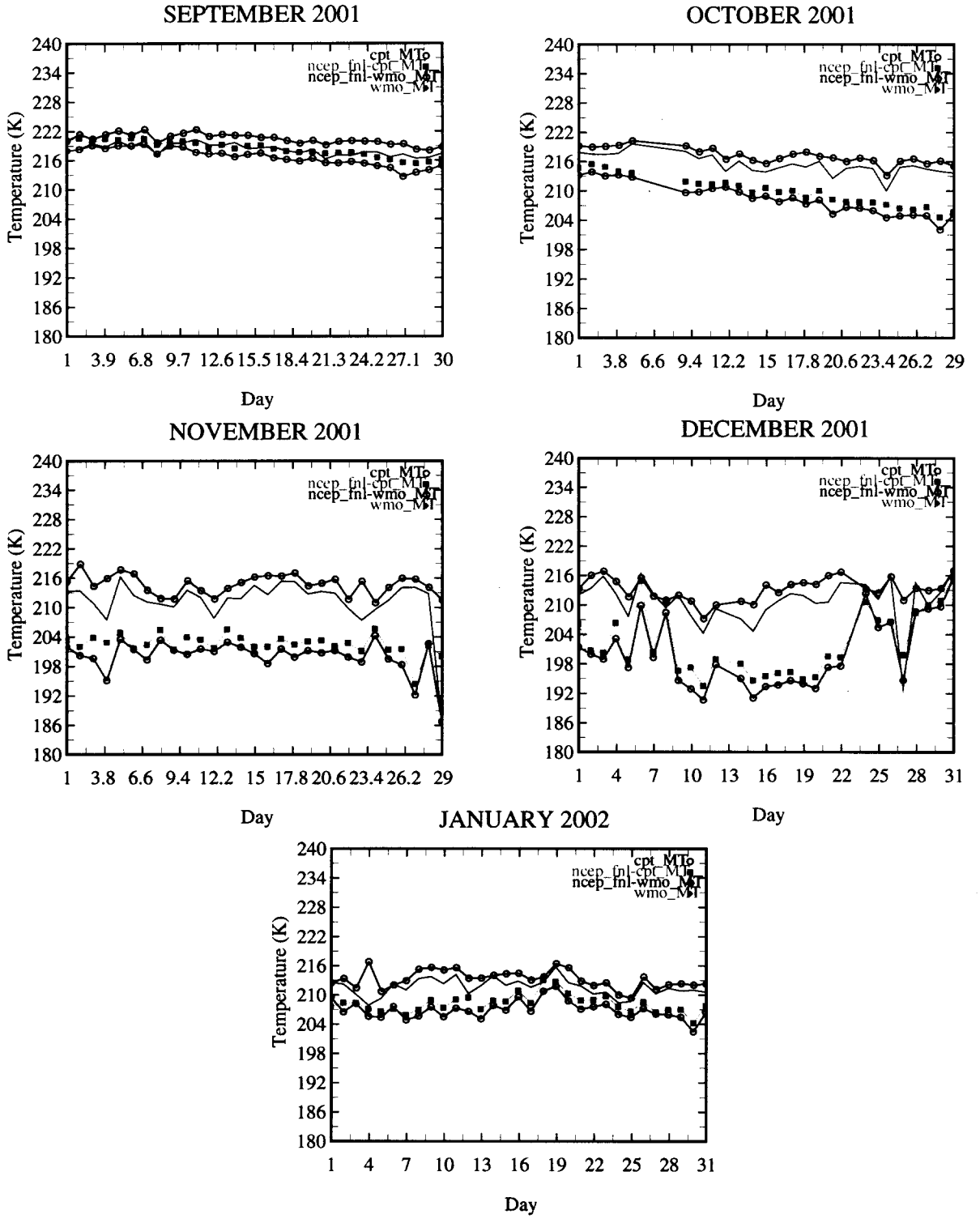

Figures 3: Temperatures at the coldest point and at the tropopause as the polar night sets according to NCEP and OCCULTATIONS.

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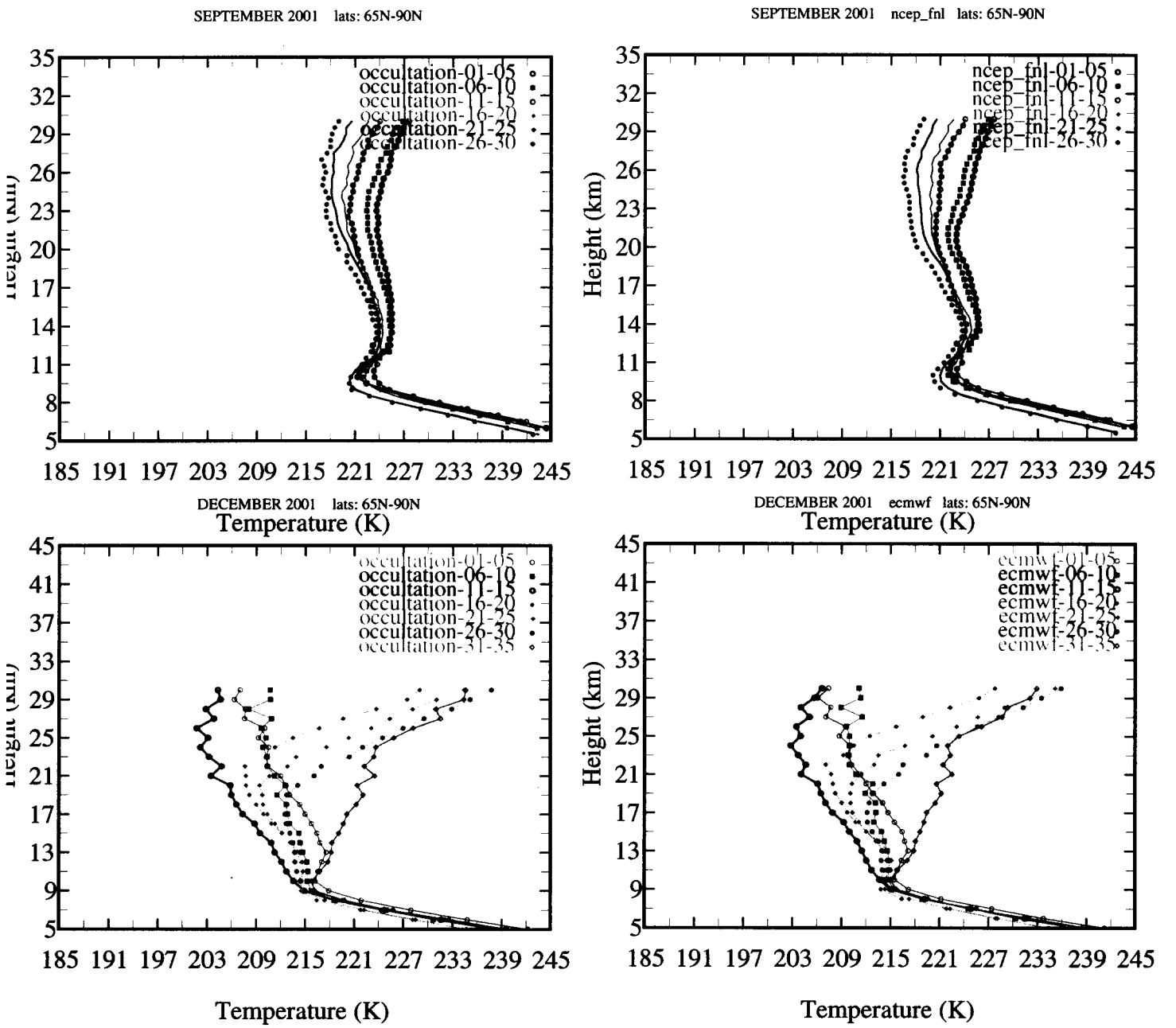

Figures 4: Evolution of the temperature profiles as a function of height and time for SEPTEMBER 2001, and DECEMBER 2001: The temperature profiles show a large region nearly isothermal in analyses and occultations.

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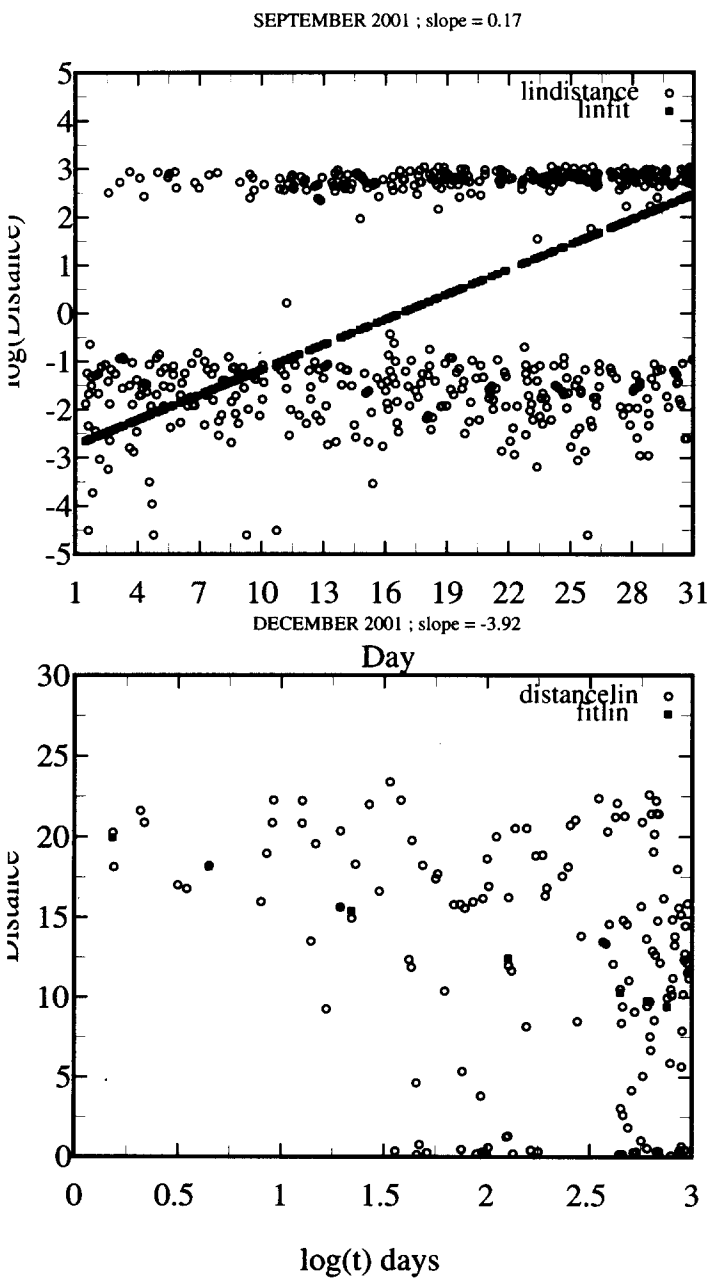
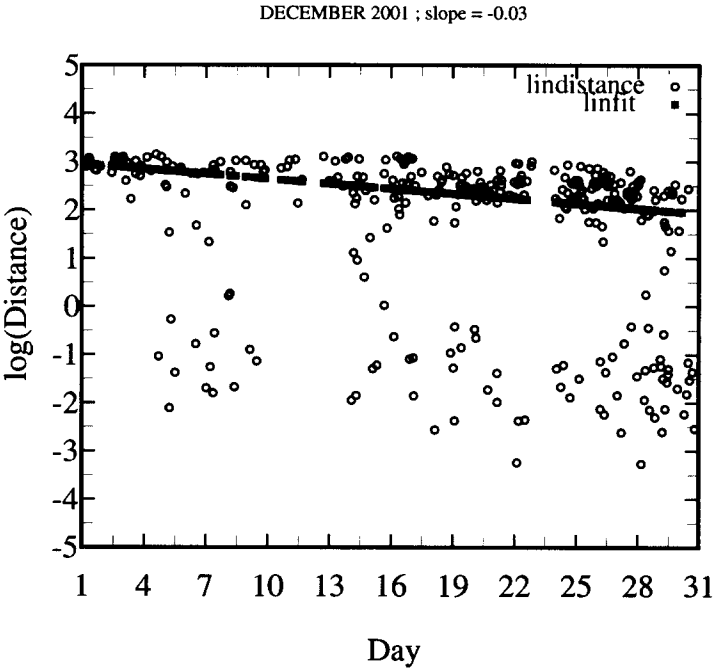




Figures 5: Evolution of the tropopause thickness D: D is defined as the intermediate region between the height where the lapse rate becomes smaller than a certain value (2K/km) for at least 2 km, and the location where the temperature inversion is reached. The fits were made to points that were less than 1 standard deviation from the fit line.

Models of the dynamical tropopause predict its thickness. Neglecting advective processes, the tropopause thickness D can be described by:

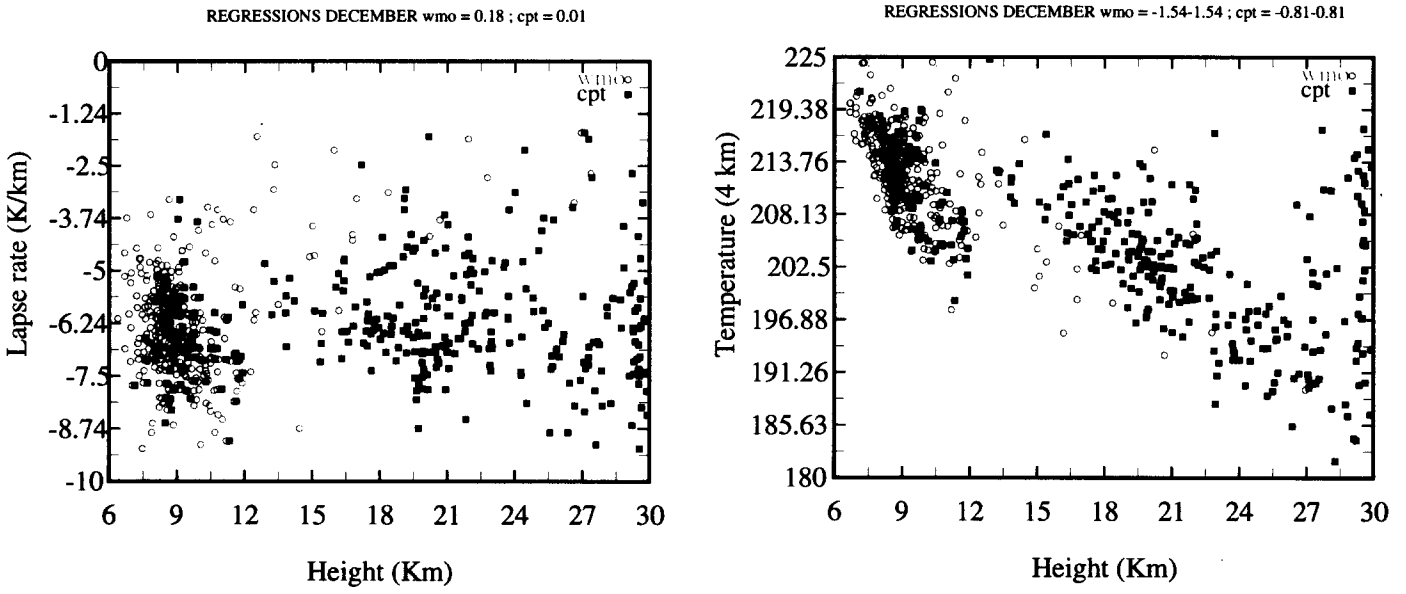
$$\frac{\partial D}{\partial t} = -\frac{D^2}{\delta q}\frac{\partial S}{\partial n}$$

where δq is the potential vorticity, q, contrast over the width D (nearly

constant), S stands for the diabatic forcing of the potential vorticity ($\partial_t \nabla q = \nabla S$), and ∂_n indicates the derivative in the direction of the potential vorticity gradient. For Eckman friction D is expected to increase linearly with time. For diffusion of potential vorticity D, would change as a square root of time. *M. Ambaum, 1997. Isentropic Formation of the Tropopause. J. Atmos. Sci.* **54**, *555-568.*

While September shows a discontinuous process, December seems to be better described by a continuous transition.

Models of the radiative tropopause predict a height which is proportional to the difference between surface and tropopause temperatures and inversely proportional to the lapse rate below the tropopause. *J. Thuburn, G.C. Craig, 2000. Stratospheric Influence on Tropopause Height: The radiative Constraint. J. Atmos. Sci.* **57**, *17-57.*



Figures 6: Tropopause height as a function of the tropospheric lapse rate, and the temperature at 4 km altitude.

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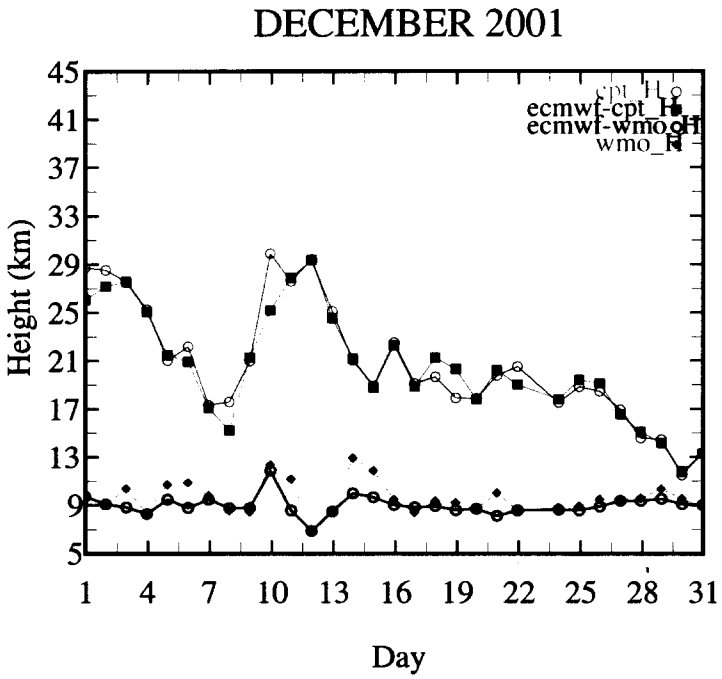
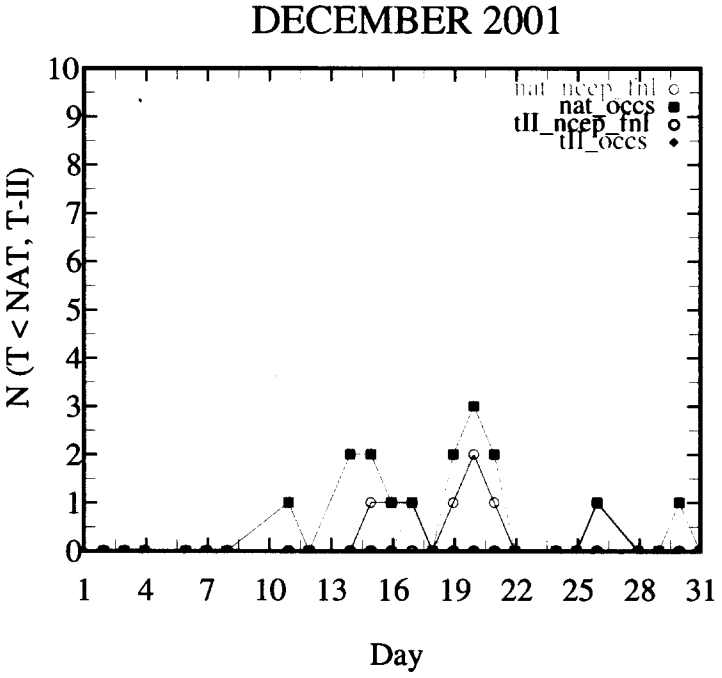
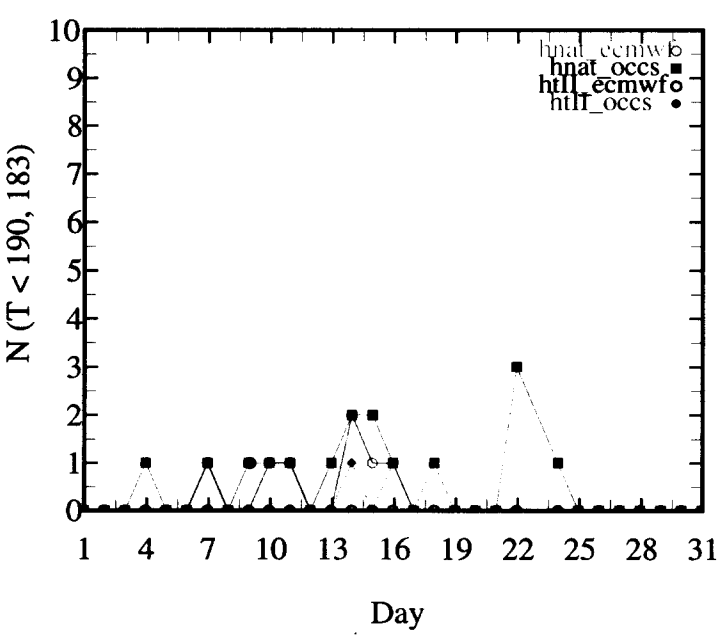
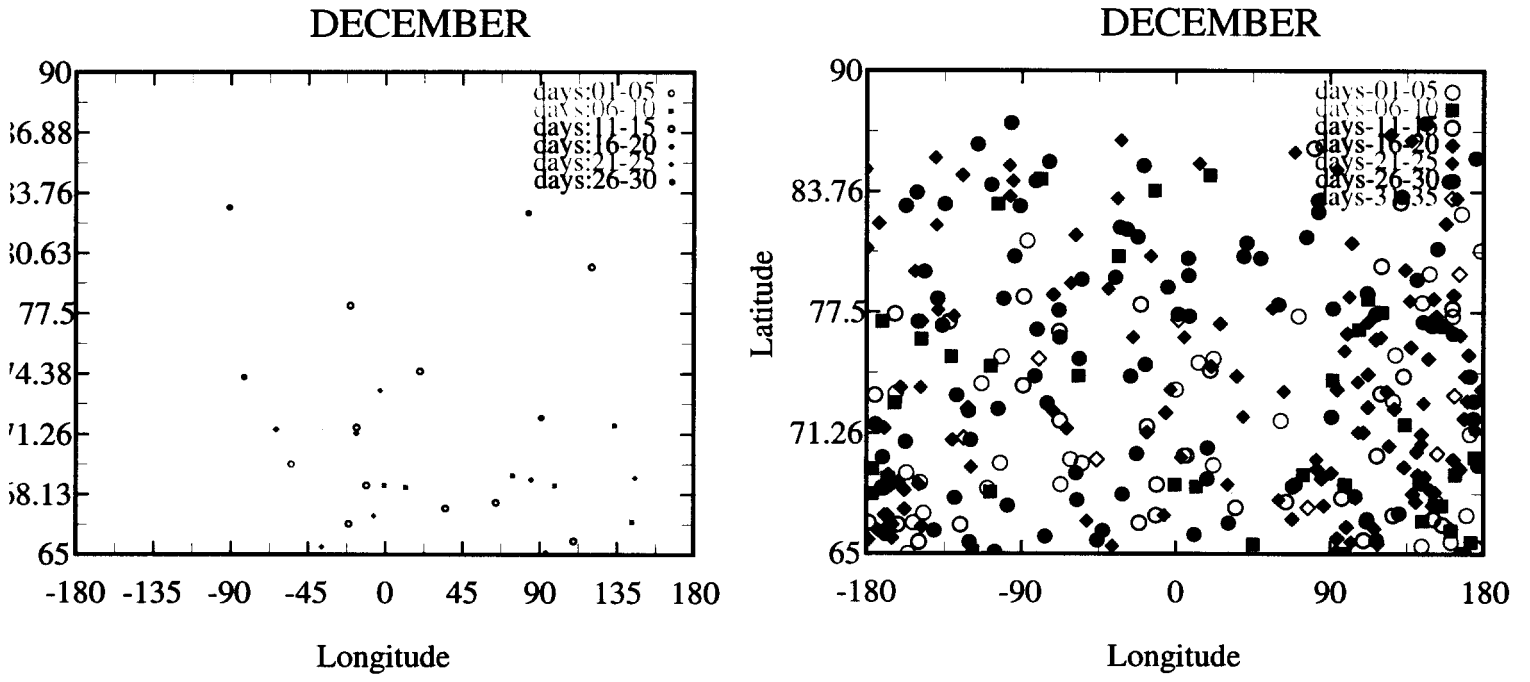
Detection of the conditions for PSC formation:







Figures 7: Comparisons between NCEP, ECMWF, and OCCULTATIONS: number of locations per day at which the conditions for PSC formation occurred in December 2001



Figures 8: Locations where PSC conditions and occultations occurred.

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Conclusions:

The arctic polar stratosphere displayed the transition between 2 different regimes in SEPTEMBER and DECEMBER. In September the point with the coldest temperature separated from the tropopause by what appears to be radiative cooling above 20 km. In December the coldest temperature appears to be found at the tropopause again. The transition in December however does not appear consistent with simple models of either radiative nor non-advective p.v. conservation.

The NCEP and ECMWF weather analyses, and radio occultations capture the general process, while they differ in some details, like the frequency with which conditions for PSC formation would exist, as well as the type of PSCs.

Acknowledgements:

The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.