Unexpected characteristics of Uranus' southern circulation revealed by 28-year old data.

E. Karkoschka[1], [1]University of Arizona (erich@lpl.arizona.edu).

Introduction: The circulation patterns of the jovian planets are essentially known except for the southern half of Uranus' southern hemisphere and the northern half of Neptune's northern hemisphere. For Neptune, the lack of data at high northern latitudes is simply due to the fact that Neptune's North Polar Region was tilted away from the sun and Earth during the last decades. After Neptune's spring equinox of 2038 we will be able to obtain better data about its northern hemisphere, up to its solstice in 2078.

Uranus in the following decades: On the other hand, Uranus' southern hemisphere is currently tilting away from us so there is no chance we will be able to learn about its circulation with new data in the next decades. We will have to wait close to the fall equinox in 2050 when the southern hemisphere will be back. The winter solstice in 2069 will provide the best viewing on southern latitudes.

Uranus' southern hemisphere was tilted well toward the sun and Earth during the 1980's and 1990's. Yet, the only trackable feature on Uranus south of 45° South was a less reliable data point based on Voyager imaging [1]. North of 45° South, Uranus' circulation is known without major gaps [2]. Clearly, the southern latitudes of Uranus are unusual. The only hope to measure Uranus' southern circulation lies in data from the last century.

Search in previous data: A search in most of the HST images of Uranus of the 1990's did not reveal a trackable feature south of 45° South.

However, a search among 1600 Voyager images of 1985/1986 revealed dozens of new features in addition to the one that was revealed in 1986. All the new features are of low contrast, on the order of 0.1 %, and thus not visible in single images. They are detectable through refined calibration and analysis techniques and by co-adding all or many of the 1600 of images, increasing the signal-to-noise ratio by two orders of magnitude.

Most of the features are best visible in blue light, where few images have been taken since 1986. They have different characteristics such as shape and size compared to features seen at longer wavelengths. In the blue, we probe variations of aerosols, such as aerosol size. At longer wavelengths, we probe the vertical distribution of aerosols due to methane absorption.

Tracking of these features defines the circulation south of 45° South without any major gap exceeding 3° of latitude. Thus, Uranus' circulation is known now. It has remarkable, unexpected characteristics.

Results for the circulation of Uranus:

1) Uranus' circulation profile has three sharp corners, while previous data of both ice giants suggested smooth curves.

2) Uranus' circulation has a 10°-wide latitude region of essentially constant rotation rate, the first such region that has been detected on any jovian planet. This is inconsistent with a Hadley cell going across the southern hemisphere, the current best model.

3) Uranus' circulation has a north-south asymmetry of about 20 % of the interior rotational rate. All known asymmetries on jovian planets have been on the order of 1 % or less. How can one region of Uranus be so different from the rest of the jovian planets?

4) The fastest rotating feature on Uranus rotates 5 h faster than the interior rotation, 2 h faster than the fastest known feature on Uranus. No other jovian planet shows such large deviations from the interior rotation, although Neptune comes close.

Implications for research in future decade(s):

1) If the unusual circulation pattern on Uranus is seasonal, it should form in front of our eyes on the northern hemisphere within the next 15 years. We certainly want to know if, when, and how this happens.

2) Observations of Uranus may reveal new kinds of features with creative, unconventional observing and analysis techniques.

3) Uranus shows unique features in blue light that are not visible at longer wavelengths. HST can do this, JWST cannot.

4) Old data are worthwhile analyzing. Techniques and computer power have improved so much that new ground can be achieved.

5) Knowledge of the characteristics of the detected features may allow us to detect them in existing HST and ground-based images.

6) Understanding the circulation pattern of Uranus will require new modeling work. The unusual characteristics of the pattern may reveal insights that may not be obtainable anywhere else.

7) On Uranus, a relative minor extrapolation from data for most latitudes to the rest of the planet failed miserably. Modeling of objects such as exoplanets before data exist requires typically larger extrapolations. Whether they fail miserably too or not can only be decided with data.

References:

[1] Smith, B.A. et al. (1986) *Science*, *233*, 43-64.

[2] Sromovsky, L.A., Fry, P.M., Hammel, H.B., de Pater, I., Rages, K.A. (2012) *Icarus*, *220*, 694-712.