Ice Giants Workshop at the 2015 DPS Meeting

Recent Uranus results from Keck and HST/STIS observations

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Keck results presented in recent Icarus papers:

Record-breaking storm activity on Uranus in 2014

In 2014 Keck detected brightest storm ever in K’, reflecting 23% of Uranus total.

We also saw fading of the South polar cap and rapid development of a northern polar cap.

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High S/N imaging of Uranus from Keck and revealed new weather phenomena in unprecedented detail.
These maps of Keck observations from 2012-2014 display many interesting persistent waves and other cloud features. A discussion of these and long-term tracking results are presented in Pat Fry’s poster (311.01).
Keck NIRC2 Observations revealed striking polar cloud asymmetries that are highlighted in Heidi Hammel’s poster talk (311.02)

![Image of polar cloud asymmetries](image)

The abundance of small clouds seen in the northern hemisphere 5 years after equinox contrasts with the complete absence of such features in the southern hemisphere 4 years before equinox.
New circulation measurements also reveal striking polar asymmetries:
Accurate solid body rotation is found in the north polar region of “popcorn” cumulous. Much different circulation found from reanalysis of Voyager-2 data (Karkoschka 2015).
If the large north-south asymmetry in circulation is due to seasonal effects, by the next solstice (in 2030), the north polar circulation should transition to what the south looked like in 1986 (prior solstice).

Speculated alternate scenarios for seasonal circulation transition:

**A**
Projected changes in drift rate using linear interpolation to a reversed southern-hemisphere profile at the next northern summer solstice.

**B**
Projected changes in drift rate using interpolation to a reversed southern-hemisphere profile at the next northern summer solstice, assuming expansion from a divergence at 71.5°N.
Methane asymmetries?

Using HST/STIS spectral imaging, Karkoschka and Tomasko (2009) showed that in 2002 the methane mixing ratio on Uranus was substantially depleted in the south polar region compared to low latitudes.

When the north polar region came into view and exhibited striking and possibly seasonal asymmetries in cloud structure, it seemed plausible that the north polar region might not be depleted in methane.
In 2012 we got HST/STIS time to look at the northern hemisphere of Uranus and were surprised to find that it also was depleted in methane (Sromovsky et al., 2014).

We also got HST/STIS time in 2015 to better define the vertical distribution of the methane depletion and its horizontal structure, which might be related to ortho para variations induced by vertical motions.
HST WFC3 observations were made on 11 Oct 2015 for the purpose of calibrating STIS hyper-spectral images of Uranus aimed at defining polar methane depletion.

These are a subset with better contrast but show no significant storm activity.

Sample STIS spectrum with slit aligned with polar axis (analysis is underway).
The most recent Keck observations (Imke de Pater) show less storm activity than in 2014, but still can detect small polar cloud features.
Key recent results from Keck and HST/STIS

Detection of recent **intense storm activity in 2014**, some detected by amateur astronomers (relatively quiet in 2015, but what comes next is uncertain).

Detection of **north polar cap formation** (also seen by amateurs).

Cloud **structures not previously seen** were detected by high S/N AO imaging, including waves and persistent discrete features, as well as transient features.

An abundance of small near-IR cloud features were found in the north polar region (and not ever seen in the south polar region).

Characterization of **large hemispheric asymmetry in cloud morphology** and structure.

Measurement of **solid body rotation in the north polar region** where small cloud features are abundant.

Identification of **large hemispheric asymmetries in circulation** (future large changes in north polar circulation are plausibly expected).

Measurement of **polar depletion of methane** (more detailed analysis of north polar region is underway).