Abstract for EPSC 2020: OPS1

Jupiter's south polar region (~60-80ºS): Wind patterns from JunoCam maps

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Introduction

Previous studies of Jupiter's wind patterns, from the Hubble Space Telescope and Cassini, revealed the southernmost two prograde jets at 58ºS and 64ºS (planetocentric), which we now designate as the S5 and S6 jets. A few degrees further south they showed a retrograde flow, but the wind pattern further poleward was not well defined. It is important to characterise the flows in this region in order to understand the dynamics of the polar atmosphere and the processes that maintain the pentagon of cyclones around the south pole [1,2]. Here we use Juno (JunoCam) images to characterise the S5 and S6 jets and the wind patterns further south, up to the edge of the pentagon.

JunoCam takes hi-res images over the south polar region (SPR) at every perijove (PJ), which reveal the typical patterns of the region, in RGB and usually in the 0.89-µm CH_4 absorption band. For each perijove we [G.E.] convert the RGB images into south polar projection maps, which can be 'blinked' or animated to visualise motions over ~0.5 to 2 hours. They are also compiled into a composite map of most of the SPR. We use maps that go down to 60ºS at the edges (and further at the corners so part of the S5 jet is included).

Organisation of the SPR [e.g. Fig.1]

Here we summarise general conclusions from JunoCam at all perijoves up to PJ23, from alignments of the RGB maps, the wind motions in animations, and the CH_4 maps.

The S5 jet is narrow and coincides exactly with a slightly sinuous boundary in methane images, the band to the south being methane-dark. The S6 jet is faster, broader and highly undulating in latitude. It generally coincides with the sinuous edge of the methane-bright South Polar Hood (SPH). In CH_4 maps the wave pattern previously recorded [3] is always present around most or all of the circumference, with greater or lesser regularity. Often the pattern is regular with wavelengths of 20-36º longitude (the mean from 8 perijoves is 25.5º ±2.6º) and amplitudes up to 3º latitude peak-to-trough.

The SPR in RGB is dark, with an irregular edge that lies between the S5 and S6 jets. It appears relatively bluer south of the S6 jet, apparently because SPH overlying it is a relatively bluish haze.

Poleward of the S6 jet, there is an irregular cyclonic belt of folded filamentary regions (FFRs) at ~65-70ºS. They show typically rapid circulation and the retrograde part of this along their south edges could be regarded as a retrograde jet at ~71ºS; however this is only present within the FFRs, not between them. Several AWOs are usually present close to the south edge of this belt of FFRs.

Further south, where the dominant features are scattered irregular FFRs and a few anticyclonic white ovals (AWOs), there are no permanent nor rapid nor extended jets. There are sometimes short, weak prograde flows in mid-latitudes, ~74-77ºS, a few tens of degrees long. Some of these appear to be merely the flanks of flows within FFRs just to the south; others are oblique. There is no jet around the south polar pentagon.

Wind-speed measurements [e.g. Fig.2]

For each of PJ15, PJ16, and PJ17, a pair of single-image maps was aligned and blinked, and hundreds of points were marked on each map manually for feature tracking. Points were chosen on and near the most rapid currents, i.e. the peaks of the S5 and S6 jets and the outer parts of FFRs, so as to define these flows.

We find that the S6 jet is rapid at all longitudes, and of variable width. It traces large waves in latitude, generally coinciding with the wave pattern around the edge of the methane-bright SPH, though with a few local exceptions. Mean peak wind speeds (measured along the jet rather than strictly eastward) range from 42 (±12) to 49 (±11) m/s. These are higher than previous speeds from Cassini and HST (25 to 42 m/s), probably because those were zonal averages diminished by the sinuosity of the jet. This sinuosity of the S6 jet (and more weakly, the S5 jet) contrasts with the straight flow of all lower-latitude prograde jets.

Wind speeds were also measured in FFRs in the main belt and further south. They were generally in the range of ~20-60 m/s, without obvious dependence on wind direction or latitude. Mean speeds in each FFR ranged from 31 to 43 m/s, averaging 37 (±13) m/s. (However, more diverse speeds may exist in some unmeasured FFRs.) These speeds are comparable to those measured in other cyclonic structures at lower latitudes.

Conclusions

The S6 jet is highly sinuous, coinciding with the prominent waves around the edge of the methane-bright SPH. There are no prograde jets closer to the pole. A belt of FFRs immediately south of the S6 jet includes fast retrograde speeds around ~71ºS.

The JunoCam maps alone cannot trace slower motions of larger features, notably FFRs, but this can be partially achieved with inclusion of ground-based maps: see our companion abstract in session ODAA3 [4].

References

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Fig.1. Polar projection map from PJ20. Yellow circles mark the circumpolar cyclones. Inset: CH_4 map at reduced scale.

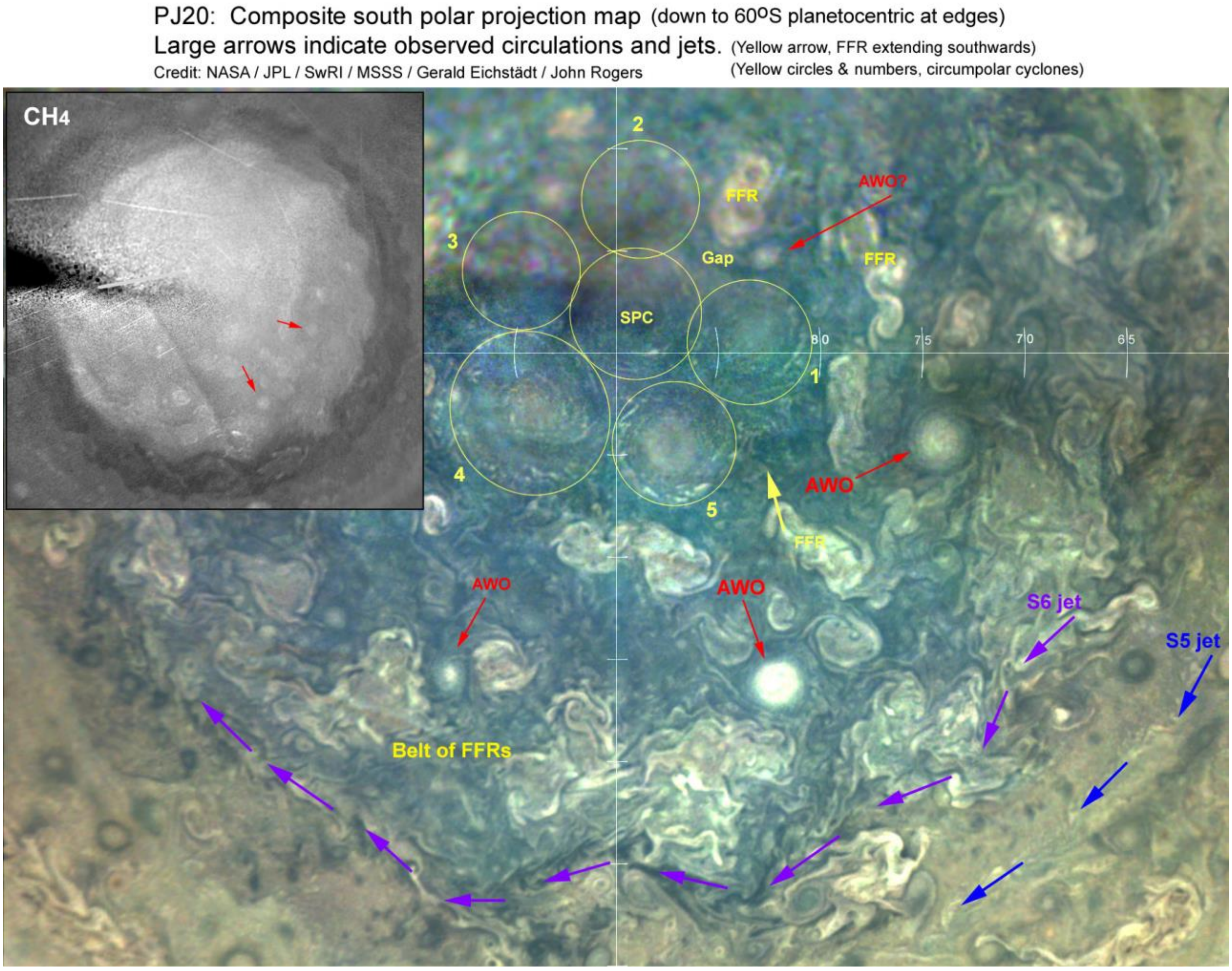
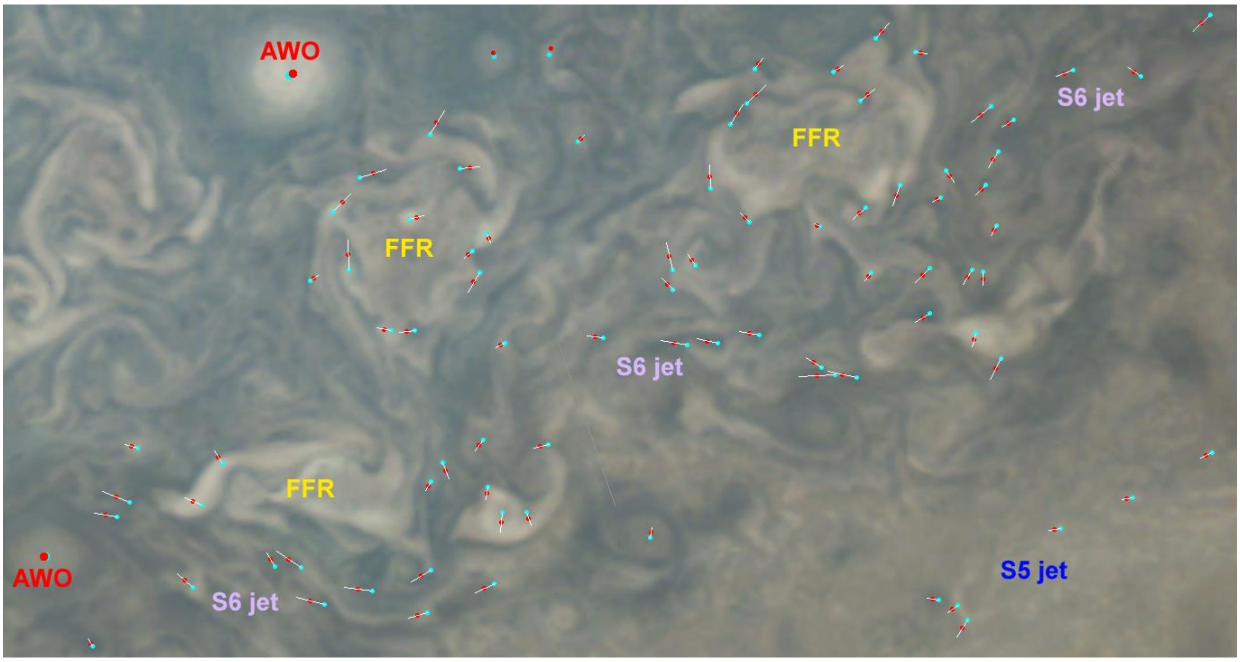


Fig.2. Excerpt from a map at PJ16 with points measured for feature tracking indicated.



Abstract for EPSC 2020: ODAA3

Jupiter's south polar region (~60-75ºS): Medium-term flow patterns from amateur and JunoCam maps

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Introduction

The Juno mission has given the first opportunity to characterise the flow patterns in Jupiter's south polar region (SPR). Fast winds can be measured by comparing hi-res JunoCam images over up to 2 hours within a single pass, which shows in detail the motion of the southernmost jet at 64ºS (all latitudes planetocentric), and the circulations of cyclonic folded filamentary regions (FFRs) and anticyclonic white ovals (AWOs) further south [*1*]. However, Juno data cannot trace slower motions, in particular the drifts of these coherent circulations over days to months. Over the 53-day interval between perijoves a few AWOs can be recognised, but the interval is too long to recognise individual FFRs, which are the dominant structures of this region. The best amateur ground-based images now have sufficient resolution to identify and track some of these features. Here, we use maps and measurements from amateur images in 2016-2020, combined with JunoCam maps that provide secure identification of the features. Thus we find that pale patches in ground-based images usually represent FFRs in Juno maps, and some small light spots are AWOs.

Measurements of drifts of FFRs over days (e.g. Fig.1)

From hi-res images by several amateur observers, we made south polar projection maps using WinJUPOS [*2*]. From blinking and animating these maps, we find that features in the SPR could only be tracked using v-hi-res images at intervals of less than 5 days; FFRs cannot be confidently identified over longer gaps as they change shape and position rapidly, although they may last for weeks. With maps spaced by 2-4 days, it is possible to observe their zonal motions and changes in outline. This is best done within a few days of a Juno perijove so that the features can be identified in the Juno map.

We selected several short series of maps in 2018 April-May and 2020 April-June that gave the clearest results, mostly using I-band images by A.C. as these were most consistent.

Preliminary results show:

--Features at ~60-65ºS are prograding (around the S6 jet at 64ºS).

--Features at ~66-74ºS are retrograding (including FFRs in the belt), with speeds comparable to those of the AWOs (see below).

-- Around 66ºS, where JunoCam images often show FFRs in the belt apparently extending north towards the S6 jet, they can sometimes be observed being sheared accordingly, with the north part of the FFR prograding close to the jet (e.g. Fig.1).

Measurements of drifts of AWOs at ~70-74ºS over weeks to months

The JunoCam maps (e.g. Fig.1) show several AWOs in this latitude range at every perijove. We have tracked these white ovals from 2016 to 2018 using positions from JunoCam (our maps) and ground-based images (measurements and maps by the JUPOS team) plus a few from HST (OPAL maps). Fig.2 shows part of the chart.

The largest AWO (A) has been tracked from 2015 (pre-Juno) to 2020. Some other ovals have probably existed for at least 8 months each, regardless of latitude, although small ones cannot always be tracked between perijoves. Some ovals have merged or disappeared within the first two years of the Juno coverage. Others are seen passing each other in different latitudes in Juno maps, although we cannot tell which is which thereafter. There are also even smaller AWOs and eddies, so there may be rapid turnover by growth, wandering in latitude, and mergers or disappearance.

The resulting zonal drift profile (ZDP) is in Fig.3. These AWOs move with essentially uniform retrograde flow from 69.5-72.4ºS, [in L3, +42 (±3) deg/53d, -3.8 to -3.2 (±0.25) m/s], but at higher latitudes, above 72.4ºS, they show a steep gradient to faster (prograding) speeds. The highest-latitude and fastest speeds (spots P & E': Fig.3) are close to those of small AWOs that drift irregularly around the periphery of the south polar pentagon of cyclones at ~80ºS [*3*]. There we found one shift of -44 deg in 53d, and several of ~-29 deg in 53d.

Conclusions

The main belt of FFRs is retrograding, along with the AWOs on its S edge. On its N edge, disturbance from FFRs often extends north to the S6 jet and is entrained by the prograding jet.

The ZDP (Fig.3) resembles that of high-latitude northern domains (N4, N5)[*4*], so the belt of FFRs and the loose ring of AWOs just south of it partially retain the organised structure of regular domains, although unconfined towards the pole.

South of 73ºS, long-term zonal drifts of AWOs become prograding with a steep gradient of mean speed increasing towards higher latitudes, where it becomes comparable to drifts of AWOs around the polar pentagon.

A companion abstract in the OPS1 session [*1*] describes the short-term wind measurements derived from the JunoCam maps at individual perijoves.

References

1. J.H. Rogers et al.(2020) EPSC abstract: 'Jupiter's south polar region (~60-80ºS): Wind patterns from JunoCam maps.'
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Figure 1. Examples of maps used for tracking FFRs in 2018.

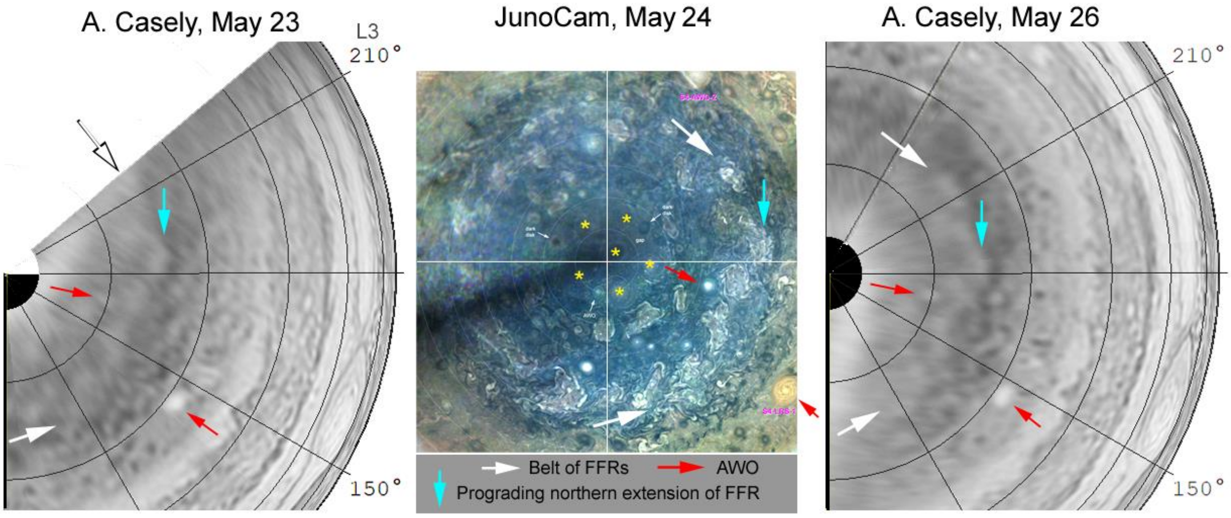

Figure 2. Excerpt from chart tracking AWOs. (L2 moves at +8.0°/30d relative to L3.)

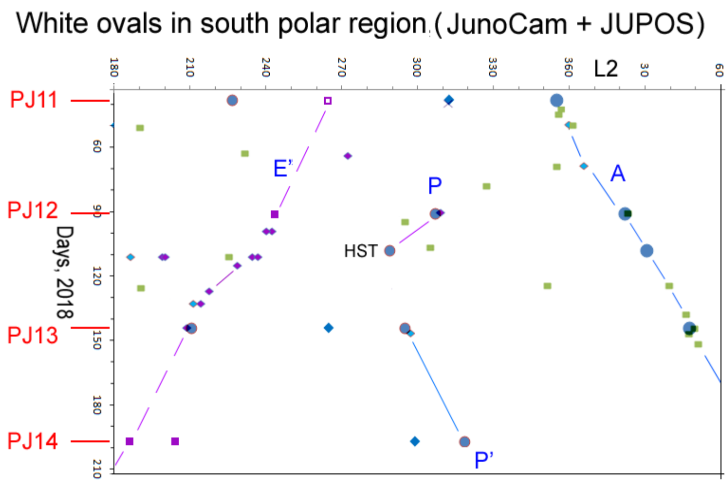

Figure 3.