public.

The images are distributed via the Canadian Astronomical Data Centre. A user can search for images by position or by name, or by the properties of the input images (number of input images, total exposure time, etc.). A preview facility is provided which allows the user to rapidly pan and zoom over the images without downloading the fairly sizable science images. A cutout service which allows users to retrieve a small subsection of a MegaPipe image is also provided.

This research used the facilities of the Canadian Astronomy Data Centre operated by the National Research Council of Canada with the support of the Canadian Space Agency.

S.D.J.G is an NSERC Visiting Fellow in a Canadian Government Laboratory.

Based on observations obtained with MegaPrime/MegaCam, a joint project of CFHT and CEA/DAPNIA, at the Canada-France-Hawaii Telescope (CFHT) which is operated by the National Research Council (NRC) of Canada, the Institute National des Sciences de l'Univers of the Centre National de la Recherche Scientifique of France, and the University of Hawaii.

Facilities: CFHT.

A. Appendix: Transforming from pixel coordinates to celestial coordinates

This appendix briefly outlines the process of going from pixel coordinates to celestial coordinates taking non-linear distortion into account with the World Coordinate System FITS keywords as used in MegaPipe. While this is discussed in an article written by Calabretta et al. (2004), this article has not yet been published.

Let (X, Y) be the input pixel coordinates. The first step is to transform (X, Y) using the linear part of the WCS. The linear part is expressed by `CRPIX1` and `CRPIX2` keywords, which express the offset, and the CD matrix keywords (`CD1_1`, `CD1_2`, `CD2_1`, and `CD2_2`) which express the scale, the rotation and any possible skew of the image with respect to the sky. This transformation may be written as:

$$x = \texttt{CD1\_1}\ (X - \texttt{CRPIX1}) + \texttt{CD1\_2}\ (Y - \texttt{CRPIX2}) \tag{A1}$$

$$y = \texttt{CD1\_1}\ (X - \texttt{CRPIX1}) + \texttt{CD2\_2}\ (Y - \texttt{CRPIX2}). \tag{A2}$$

While the coordinates (X, Y) are measured in pixels, the coordinates (x, y) are measured in degrees.

The second step is to apply the distortion. In general, the distortion can be written as:

$$\xi = f(x, y) \tag{A3}$$

$$\eta = g(x, y). \tag{A4}$$

In the simplest case, with no distortion, these equation are just

$$\xi = x \tag{A5}$$

$$\eta = y. \tag{A6}$$

Using the `PVn_n` formalism for ξ we have

$$\xi = PV1\_0 \tag{A7}$$

$$+\ \texttt{PV1\_1}\ x \tag{A8}$$

$$+\ \texttt{PV1\_2}\ y \tag{A9}$$

$$+\ \texttt{PV1\_3}\ r \tag{A10}$$

$$+\ \texttt{PV1\_4}\ x^2 \tag{A11}$$

$$+\ \texttt{PV1\_5}\ xy \tag{A12}$$

$$+\ \texttt{PV1\_6}\ y^2 \tag{A13}$$

$$+ \ \texttt{PV1\_7}\ x^3 \tag{A14}$$
$$+ \ \texttt{PV1\_8}\ x^2y \tag{A15}$$
$$+ \ \texttt{PV1\_9}\ xy^2 \tag{A16}$$
$$+ \ \texttt{PV1\_10}\ y^3. \tag{A17}$$

while for η we have

$$\eta = PV1\_0 \tag{A18}$$
$$+ \ \texttt{PV2\_1}\ y \tag{A19}$$
$$+ \ \texttt{PV2\_2}\ x \tag{A20}$$
$$+ \ \texttt{PV2\_3}\ r \tag{A21}$$
$$+ \ \texttt{PV2\_4}\ y^2 \tag{A22}$$
$$+ \ \texttt{PV2\_5}\ xy \tag{A23}$$
$$+ \ \texttt{PV2\_6}\ x^2 \tag{A24}$$
$$+ \ \texttt{PV2\_7}\ y^3 \tag{A25}$$
$$+ \ \texttt{PV2\_8}\ xy^2 \tag{A26}$$
$$+ \ \texttt{PV2\_9}\ x^2y \tag{A27}$$
$$+ \ \texttt{PV2\_10}\ x^3. \tag{A28}$$

where $r = \sqrt{x^2 + y^2}$. Including the terms up to A10 and A21 express a linear distortion, including the terms up to A13 and A24 express a second order distortion, and including the terms up to A17 and A28 express a third order distortion.

In principle, the lower order distortion terms are redundant with the `CDn_n` matrix. However, most of the currently available software does not take into account the `PVn_n` values when doing WCS calculations. Therefore, in practice, the best approach is to set the

CDn_n matrix to values that give the best linear approximation of the distortion, and use low-order PVn_n keywords to set the linear part of the higher order distortion.

Having computed the (ξ, η) from (x, y) via the equations above, the last step is to transform (ξ, η) into (RA,Dec). For the tangent projection (the one used for MegaCam/MegaPipe images), this transformation may be expressed

$$
\begin{aligned}
\alpha' &= \tan^{-1} \frac{\xi / \cos(\texttt{CRVAL2})}{1 - \eta \tan(\texttt{CRVAL2})} && \text{(A29)} \\
\mathrm{RA} &= \alpha' + \texttt{CRVAL1} && \text{(A30)} \\
\mathrm{Dec} &= \tan^{-1} \frac{(\eta + \tan(\texttt{CRVAL2})) \cos \alpha'}{1 - \eta \tan(\texttt{CRVAL2}))}. && \text{(A31)}
\end{aligned}
$$

To reverse the process, the steps are applied in reverse. First, (RA,Dec) is converted to (ξ, η):

$$
\begin{aligned}
\eta &= \frac{1 - \tan(\texttt{CRVAL2}) \cos(\mathrm{RA} - \texttt{CRVAL1}) / \tan(\mathrm{Dec})}{\tan(\texttt{CRVAL2}) + \cos(\mathrm{RA} - \texttt{CRVAL1}) / \tan(\mathrm{Dec})} && \text{(A32)} \\
\xi &= \tan(\mathrm{RA} - \texttt{CRVAL1}) \cos(\texttt{CRVAL2}) (1 - \eta \tan(\texttt{CRVAL2})). && \text{(A33)}
\end{aligned}
$$

Second, the distortion correction is made to transform (ξ, η) to (x, y). Equations A7 through A28 must be inverted. Except for certain simple cases, the easiest way do to this is by iterating with Newton's method. Since the distortion is generally only slight, using initial values of $x = \xi$ and $y = \eta$ results in convergence in only 2-3 iterations.

Finally, the (x, y) coordinates are transformed to the pixel coordinates (X, Y):

$$
\begin{aligned}
X &= \texttt{DC1\_1}\ x + \texttt{DC1\_2}\ y + \texttt{CRPIX1} && \text{(A34)} \\
Y &= \texttt{DC2\_1}\ x + \texttt{DC2\_2}\ y + \texttt{CRPIX2}. && \text{(A35)}
\end{aligned}
$$

where the `DCn_n` coefficients are found by inverting the `CDn_n` matrix:

$$\begin{bmatrix} \texttt{DC1\_1} & \texttt{DC1\_2} \\ \texttt{DC2\_1} & \texttt{DC2\_2} \end{bmatrix} = \begin{bmatrix} \texttt{CD1\_1} & \texttt{CD1\_2} \\ \texttt{CD2\_1} & \texttt{CD2\_2} \end{bmatrix}^{-1} \tag{A36}$$