A Three-Dimensional Sunspot Classification System

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In 1966, Patrick McIntosh of the Space Environment Services Center of the National Oceanic and Atmospheric Administration, introduced a sunspot classification system that improved the older Zurich system. The new classifications consist of three letters. First is the Modified Zurich Class. It basically retains the old Zurich Class but G and J were removed as being redundant. A Modified Zurich Class was used rather than a totally new system to be an making it easier for observers that might be reluctant to switch to the new system. The Second letter represents an assessment of the Largest Spot of the group. This is not necessarily the leading spot, but rather the LARGEST. The third letter represents an assessment of the Spot Distribution within the group. It takes only slightly longer than the old system to classify all the groups on the sun for a given day using the McIntosh System, but the information returned, and usefulness of the new system, makes it worth the slightly added effort.

In order to understand the McIntosh Classification system better, two terms have to be defined:

Unipolar Sunspot Group

This is a single spot or compact cluster of spots with the greatest separation between spots being less than 3 heliographic degrees (degrees on the Sun's surface). With a Class H group the separation is taken to be the distance between the outer border of the main sunspot penumbra and the most distant attendant umbra.

Bipolar Sunspot Group

This is two or more spots forming and elongated cluster with a length of 3 or more heliographic degrees. If there is a large principal spot then the cluster should be greater than 5 degrees in extent.

Now that we have these defined, below are the descriptive text that define the various classes in the McIntosh System. (All degrees are heliographic.)

For the Modified Zurich Classes

A – A unipolar group with no penumbra. This can be either the early or final stage in the evolution of the group.

B – A bipolar group with no penumbrae on any spots.

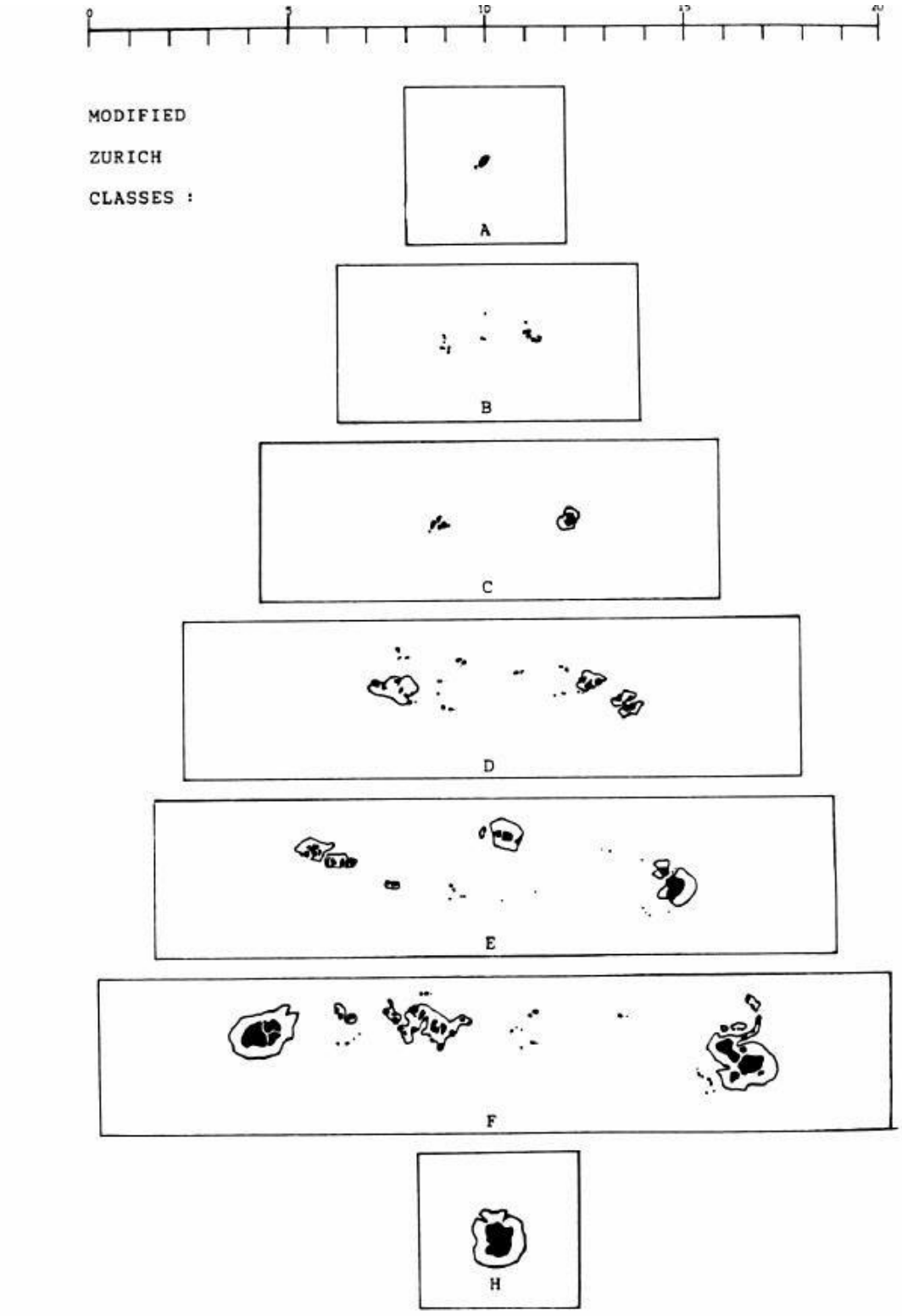
C – A bipolar group with penumbra on one end of the group, usually surrounding the largest leader umbra.

D – A bipolar group with penumbrae on spots at both ends of the group and a length of less than 10 degrees.

E – A bipolar group with penumbrae on spots at both ends of the group with a length of 10-15 degrees.

F – A bipolar group with penumbrae on spots at both ends of the group and a length greater than 15 degrees.

H – A unipolar group with penumbra, usually the remains of a bipolar group


MODIFIED
ZURICH
CLASSES :
A
B
C
D
E
F
H

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For the Largest Spot:

x – No penumbra (for groups with classes A & B)

r – Rudimentary penumbra that usually only partially surrounds the largest spot. Such a penumbra will likely be granular rather than filamentary, making it appear brighter than a mature penumbra. The width of the penumbra will only be a couple to a few granules (of the photospheric granulation) and may be either forming or dissolving.

s – Small, symmetric spot (similar to Zurich Class J) and the spot will have a mature, dark, filamentary penumbra of circular or elliptical shape with a clan sharp border. If there are several umbrae in the penumbra they will form a tight cluster mimicking the symmetry of the penumbra with a north-south diameter of 2.5 degrees or less.

a – Small, asymmetric spot with irregular surrounding penumbra and the umbrae within separated. North-south diameter of 2.5 degrees or less.

h – A large symmetric spot. Like type “s” but the north-south diameter is greater than 2.5 degrees.

k – A large asymmetric spot. Like type “a” but the north-south diameter is greater than 2.5 degrees.

(*north-south diameters are used since they suffer no foreshortening during rotation*.)

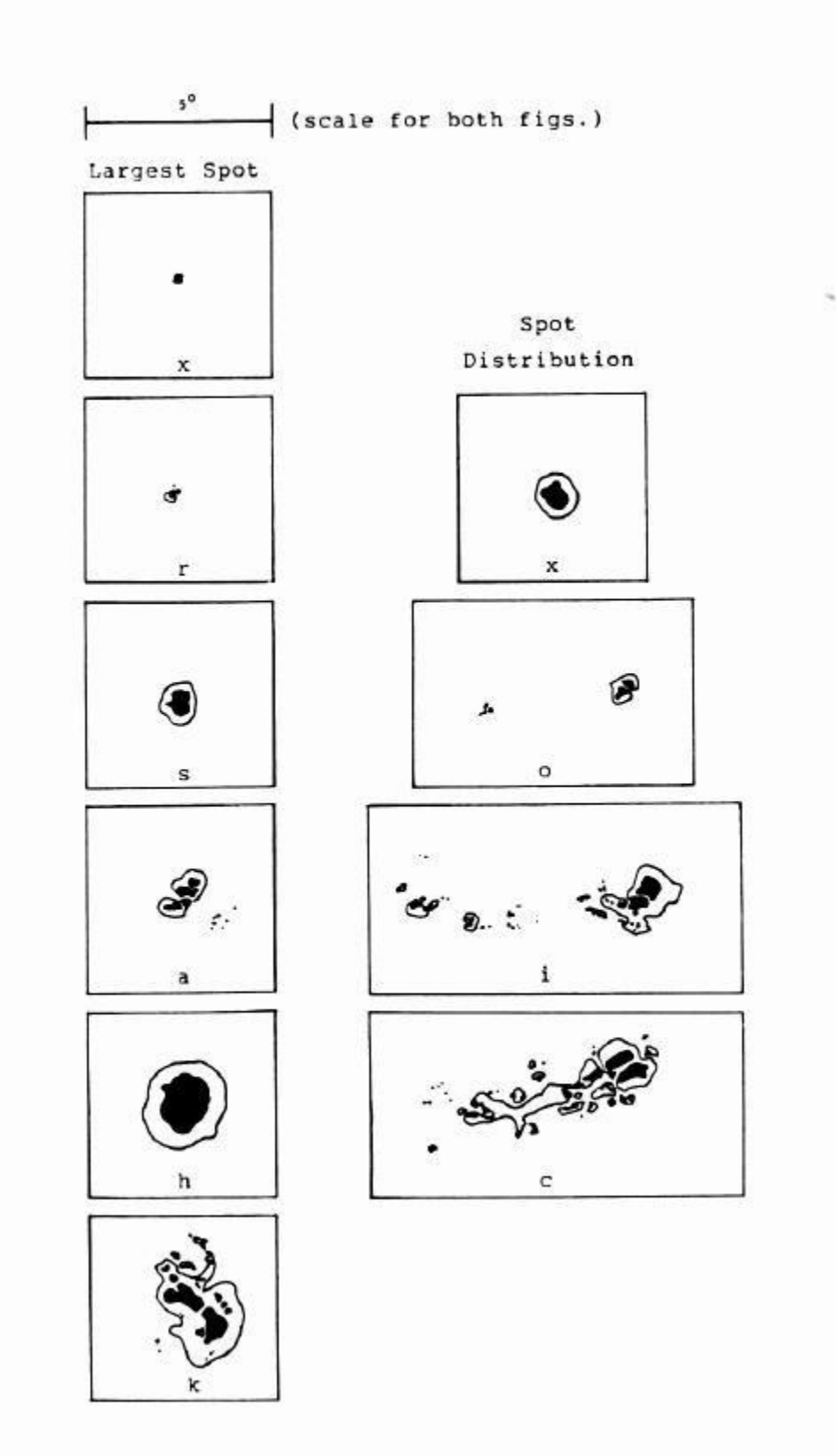
For Sunspot Distribution:

x – Unipolar group of Modified Zurich Classes A or H (i.e. a solitary spot).

o – Open distribution with a leader and follower spot and few or none between. Any spots between should be very small umbral spots.

i – Intermediate distribution where numerous umbral spots lie between the leader and follower spots.

c – Compact distribution where the area between the leader and follower spots contains many spots with at least one having penumbra. In extreme cases the whole group may be enveloped into one complex penumbra.


5°
(scale for both figs.)
Largest Spot
x
r
s
a
h
k
Spot
Distribution
x
o
i
c

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This system has proven a more accurate predictor of flares in the thirty years of its use. Indeed, it has helped solar astronomers understand better the relationship between flares and sunspots. Sunspot groups that produce flares are relatively rare. Because of this it has taken several solar cycles of observations to demonstrate the effectiveness of the new system. Using the old Zurich system it was found that groups of class F were most likely to produce flares. But only a 40% flare probability in a 24-hour period could be predicted using this parameter alone. With the McIntosh System, using Modified Zurich Class F, the probability improved to 60%. Using just the Largest Spot class of “k” the probability in 24 hours was 40-50%. If just Spot Distribution category “c” were used, flare probability went up to about 70%. But, when all three dimensions of this system were used, classes Fsi, Fki and Fkc, showed a probability of up to 100% for production of M flares in a 24-hour period and the McIntosh Class of Fkc had a further probability of up to 50% in X flares (x-ray) production! This surpasses any former method of flare prediction used, including sunspot area.