Citizen Sky

Citizen Science with Variable Stars

Astronomers need your help!

Many bright stars change in brightness all the time and for many different reasons.

Some stars are too bright for professionals to look at with most large telescopes. So, we need *your* help to watch these stars as they dim and brighten over the next several years.

This guide will help you find these bright stars, measure their brightness and then submit the measurements to assist professional astronomers.

Participate in one of the largest and longest running citizen science projects in history! Thousands of people just like you are helping out. Astronomers need large numbers of people to get the amount of precision they need to do their research. *You are the key.*

Size of Star

Size of Earth's Orbit

Size of Jupiter's Orbit

CitizenSky is a collaboration of the American Association of Variable Star Observers (**AAVSO**), the University of Denver, the Adler Planetarium, the Johns Hopkins University and the California Academies of Science with support from the National Science Foundation.

Header artwork is reproduced with permission from Sky & Telescope magazine (www.skyandtelescope.com)

Betelgeuse – Alpha Orionis

From the city or country sky, from almost any part of the world, the majestic figure of Orion dominates the night sky with his belt, sword, and club. Low and to the right is the great red pulsating supergiant, Betelgeuse (alpha Orionis). Recently acquiring fame for being the first star to have its atmosphere directly imaged (shown below), alpha Orionis has captivated observers' attention for centuries.

At minimum brightness, as in 1927 and 1941, its magnitude may drop below 1.2. Betelgeuse is a semi-regular pulsating red supergiant. It is believed to be at least the size of the orbit of Mars and at maximum diameter may possibly equal the orbit of Jupiter. The star is one of the largest known; spectroscopic studies show that the diameter of the star may vary by about 60% during the whole cycle, a difference considerably larger than the radius of the Earth's orbit!

Indeed, when at maximum, Betelgeuse sometimes rises to magnitude 0.4 when it becomes a fierce competitor to Rigel; in 1839 and 1852 it was thought by some observers to be nearly the equal of Capella. Observations in the AAVSO International Database indicate that Betelgeuse probably reached magnitude 0.2 in 1933 and again in 1942.
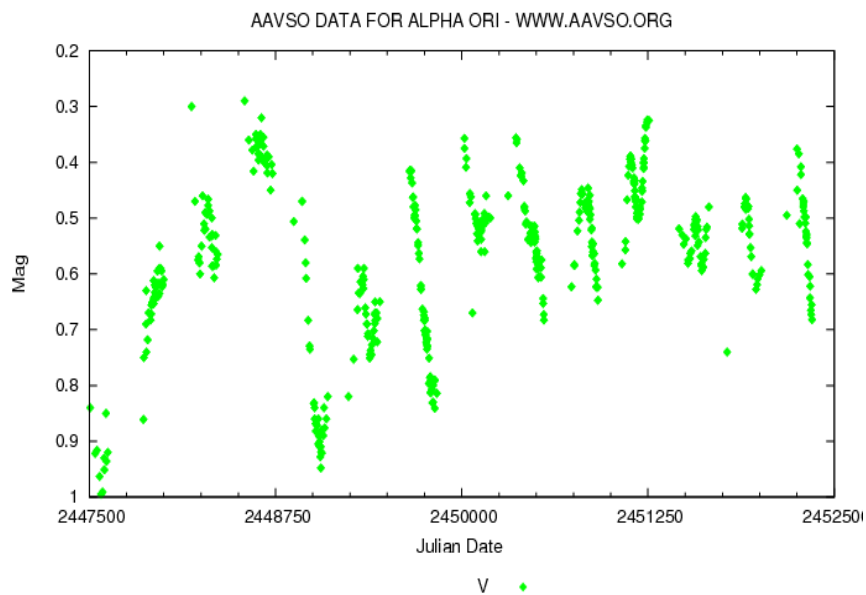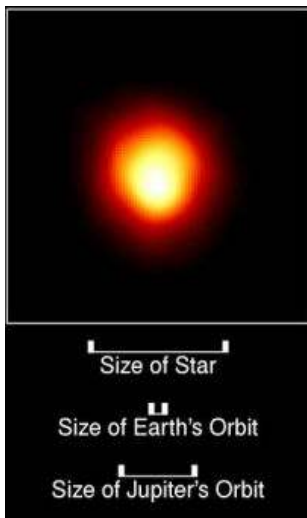
This is a *light curve*. It shows how alpha Orionis's brightness changes over time. Each of these data points is a single brightness estimate of the star made by an amateur astronomer.

Using a Star Chart.

It's easier than it looks!

A star chart is just a map of the sky. You use it to match a pattern of stars in the sky with a pattern of stars on the chart, just like you'd match a pattern of streets with those on a street atlas.

1. First, find the constellation that the variable star is in.
2. On the next page is a map of constellations in the southern sky.
3. Face South and rotate the chart so the current season is at the bottom.
4. Hold the map up against the sky and look for the constellations.
5. For alpha orionis: we suggest starting with Orion's Belt, the three stars at the center of Orion, (Alnitak, Alnilam and Mintaka) forming a straight line oriented almost East to West.
6. Once you have found that, look for alpha Orionis, a little down and to the right of Orion's Belt. The bright red star located there is alpha Orionis, whose common name is Betelgeuse.
7. Go to page #5 to learn how to make your observation.

To the left is a picture of Orion, with an arrow pointing toward Betelgeuse. To the right the constellation is outlined, with Betelgeuse and Rigel labeled.

Star chart for the Southern Horizon.
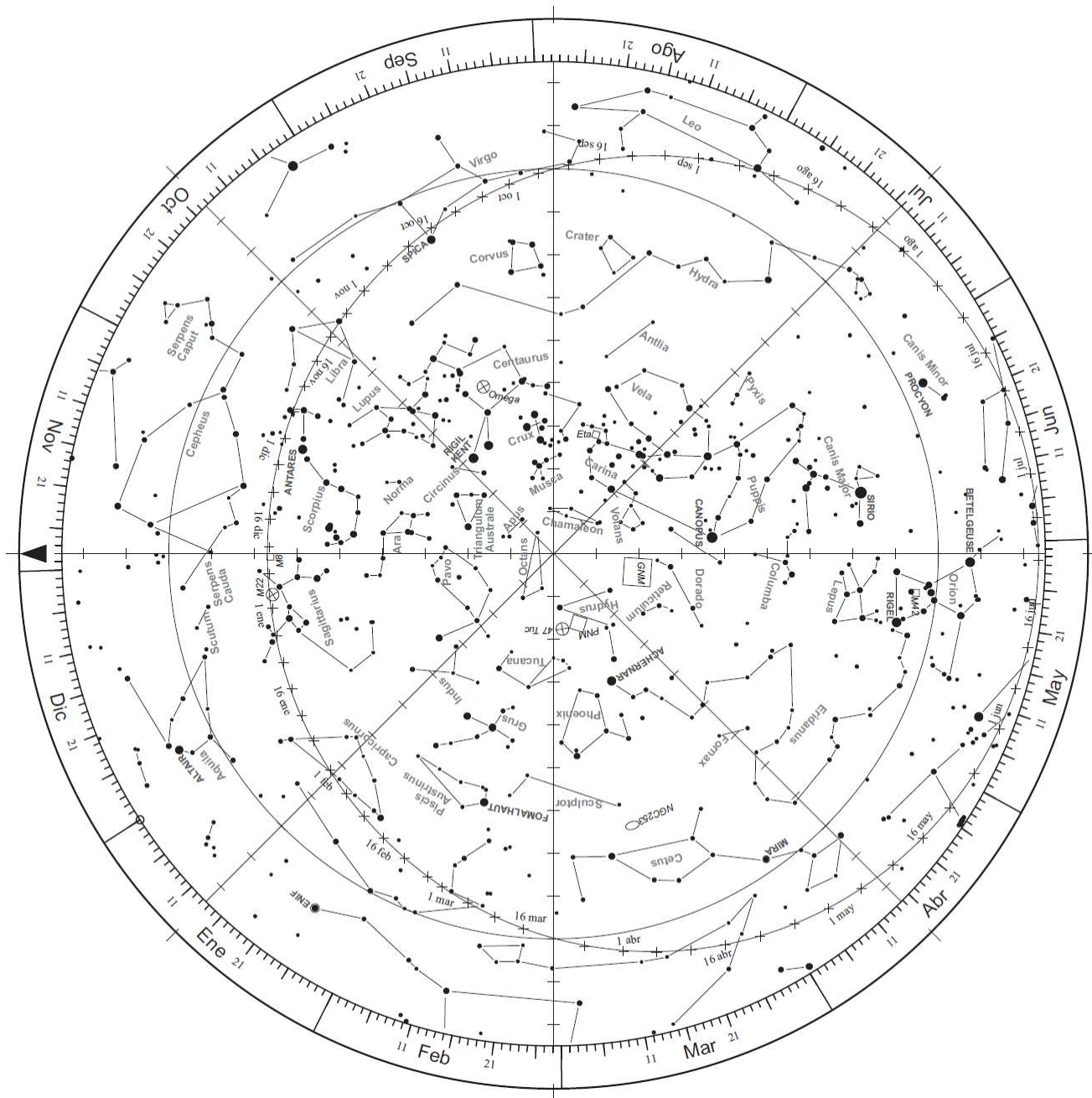
To orient yourself with the stars, face south and rotate the chart until the current season shows at the bottom. The constellations at the bottom of the chart will be in the southern sky, while the stars at the top of the chart will be to the north. This is based on midnight stargazing. As the night progresses, the stars will appear to rotate clockwise due to the rotation of the Earth.

Using a Variable Star Chart.

You found the constellation, now find the variable star. This star chart is a little different from the last one. It is "zoomed in" on the constellation Orion. It also has some information you'll need to make a brightness estimate of the star.

1. Find the stars in the constellation that look like the ones on the chart. Be patient, the first time you do this it may take a long time. It will be much easier after the first time. By the fourth or fifth observation, you won't even need the chart!
2. Find the variable star by locating the star at the cross hairs on the chart.
3. Next, find the comparison stars – the stars with numbers on them.
4. That's it! Now turn to the next page to make an estimate of the variable star's brightness.
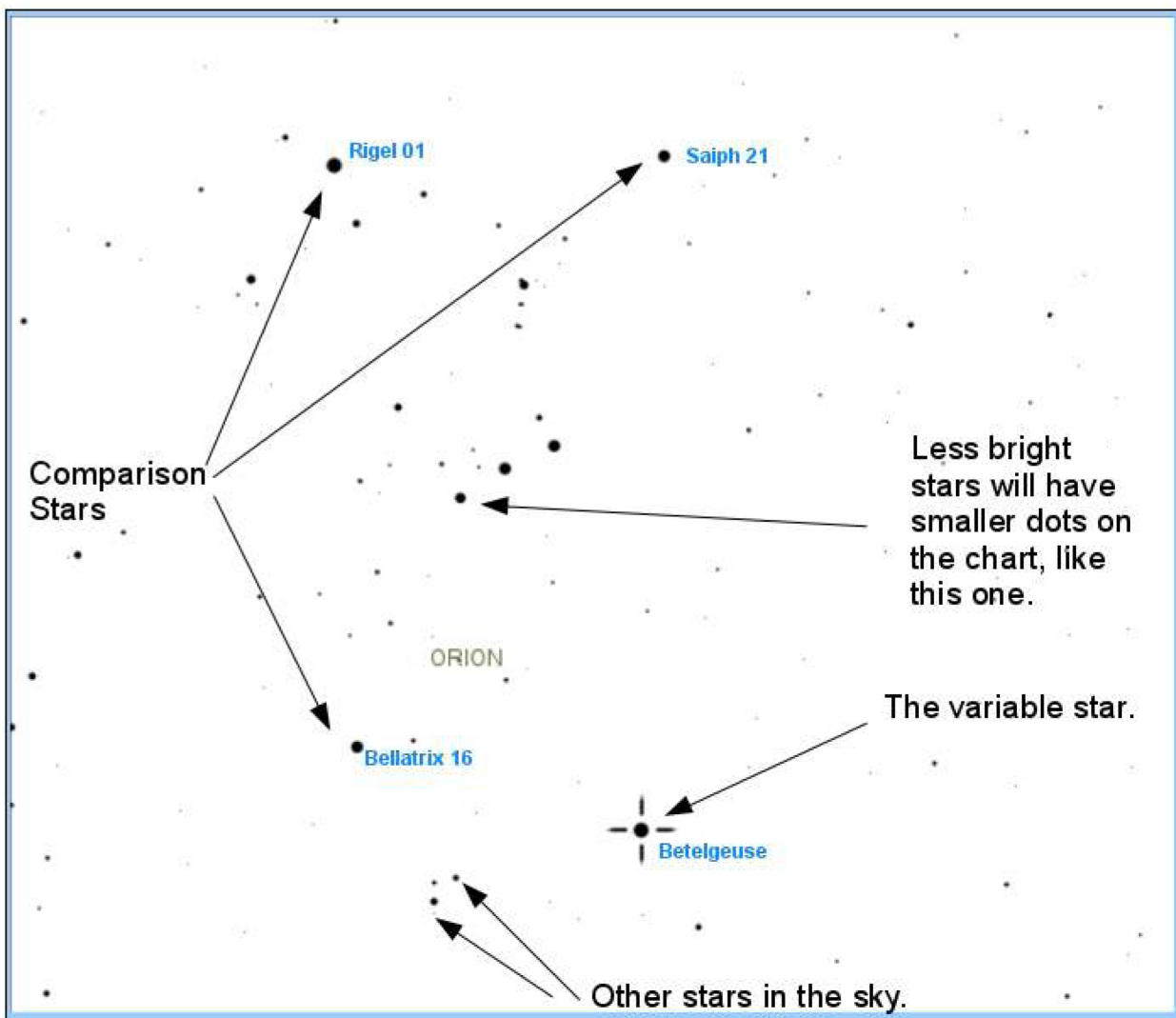
Measure a Star's Brightness

To measure a star's brightness, you simply compare it to other stars in the sky. Those other stars are called "comparison stars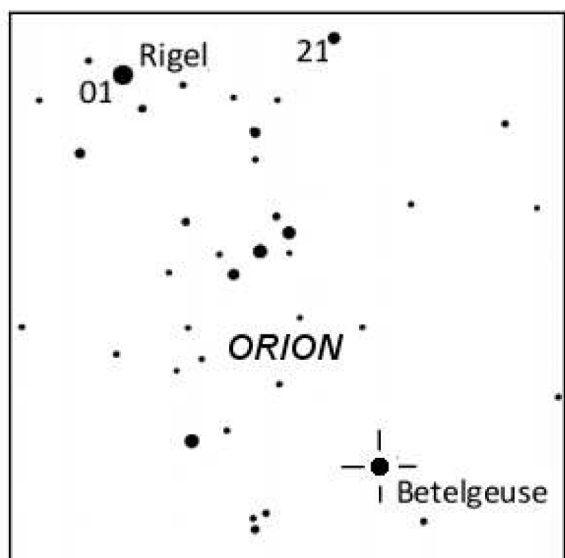" because you use them to make the comparison. Astronomers have carefully measured the brightness of the stars and assigned them a number according to their brightness. **The smaller the number, the brighter the star**.
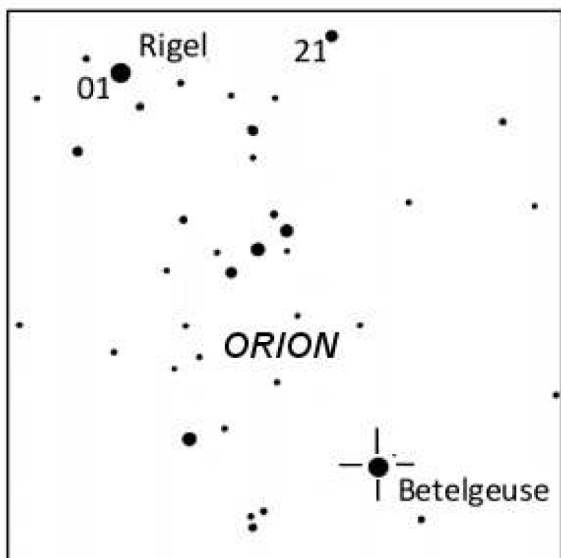
In this example, Betelguese will be close to the same brightness as Rigel, which has a magnitude of 0.1. So one may estimate Betelguese at magnitude 0.1.

In this example, Betelguese is somewhere in the middle between the 0.1 and 2.1 comparison stars. So one may estimate it somewhere in between the two numbers, say magnitude 1.1.

It is important to note that the decimal point has been left off the magnitude labels on star charts. When you report your observations, you should definitely include the decimal!

Reporting Your Observations

Once you have made an estimate, write it down in a journal. Record the day, the time and the magnitude estimate. Don't try to memorize and recall it later. This is scientific data so we need it to be as accurate as possible.

There are two ways to report your data to professional astronomers: via postal mail or the Internet.

• **Internet:** We *highly* recommend submitting your observations via the Internet. By doing so, your observations get sent to astronomers very quickly. Also, you can compare your observations to other observers immediately after you have submitted them. To submit online, log on to the AAVSO website then go to:

http://www.aavso.org/webobs/individual

Select "Visual" from the drop-down box next to "What type of Observations are you submitting?", fill out the form and click the "Submit Observation" button at the bottom of the page. If you have a question about anything, try clicking one of the "More help…" links.

It will take about 10 minutes to submit your data for the first time. Once your data is submitted, you can request a plot of your star from the Light Curve Generator (http://www.aavso.org/lcg) and see your observation plotted on the light curve. This way you can see how you compare with others and with any other data you had previously turned in. *Never look at the light curve **before** you submit your observations, as it could bias your report!*

• **Postal Mail:** If you prefer to submit your estimates via postal mail, fill out the form on the next page and mail it to the AAVSO. If you would like more forms, just ask and we will mail you new copies.

AAVSO Report Form

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
49 Bay State Road, Cambridge, MA 02138, USA

VARIABLE STAR OBSERVATIONS

Sheet _____ of _____ Report No. _____

For Month of _____ Year _____

Observer _____

Street _____

City _____ State _____

Country _____ Zip Code _____

Time Used, GMAT or _____

Instrument(s) _____

AAVSO Observer Initials

_____

For AAVSO HQ Use Only
Received _____
Entered _____
Verified _____

Variable	Date	Mag.	Key* &	Remarks	Comp. Stars	Chart ID
Alpha Ori	*Jan. 1, 2013 9:15pm*	*2.2*		*Sample observation*	*20, 25*	*10-star tutorial*
				Total Number Observations Reported		

* KEY field contains AAVSO-selected one-letter abbreviations for REMARKS. Obtain list from AAVSO Headquarters or web site.

Ten Plus One Variable Star Training Program for the Southern Hemisphere

Observing a variable star takes practice. We have designed a training program to teach you how to observe, collect data, and to record your data.

These stars are arranged in order of months when they are best observed. The first couple of months the star will be visible before sunrise or very late at night, and the last month it will have to be caught right after sunset.

Star Name	Observing Time	Range of Magnitude	Type of Variable	Period In days	Notes
X Sagittarii (X Sgr)	March to October	4.22 - 4.86	Classical cepheid	7.0129	When observing X Sagittarii, you are observing the Milky Way center, which is 1 degree South of X Sgr.
W Sagittarii (W Sgr)	March to October	4.28 - 5.09	Classical cepheid	7.595	W Sagittarii is a triple system made up of the cepheid, a close F5 dwarf, and a more distant A0 star.
eta Aquilae (eta Aql)	April to November	3.49 - 4.30	Classical cepheid	7.1769	Eta Aquilae was the first cepheid discovered. Pigott found it in 1784 (before delta Cephei discovery by Goodricke).
kappa Pavonis (kap Pav)	April to November	3.91 - 4.78	Pop. II cepheid	9.082	Kappa Pavonis is by far the brightest example of a Population II (old) cepheid. Low mass stars less luminous than classical cepheids. Kappa Pavonis displays abrupt period changes. Continuous monitoring helps track them.
zeta Phoenicis (zet Phe)	July to February	3.94 - 4.42	Eclipsing binary	1.6698	Zeta Phoenicis is an Algol-type eclipsing binary. You will find the star at maximum brightness most of the time, so catching an eclipse will require patience but will be rewarding.
beta Doradus (bet Dor)	September to April	3.41 - 4.08	Classical cepheid	9.8426	Beta Doradus is only 0.1 mag. fainter than l Car and follows it in the ranking. Classical cepheids are massive Population I (young) stars.
V Puppis (V Pup)	October to May	4.35 - 4.92	Eclipsing binary	1.4545	V Puppis is an eclipsing binary of the beta Lyrae type. Brightness changes are continuous due to the ellipsoidal shape of the components.
alpha Orionis (alf Ori)	October to May	0.2 - 1.2	Semiregular	420	Alpha Orionis is named alpha but only a couple of times in history has actually been brighter than beta Orionis (Rigel).

R Doradus *(R Dor)	October to May	4.8 - 6.6	Semiregular	338	R Doradus is a semiregular star showing two maxima and strong amplitude changes from cycle to cycle. One of the largest stars with a diameter measured interferometrically from Earth (along with Betelgeuse, the other semiregular on this list). *You will need a pair of binoculars to observe it. This is our extra star for the tutorial. It can be a transition to binocular variable stars.
I Carinae (I Car)	December to July	3.32 - 4.12	Classical cepheid	35.562	I Carinae is one of the more luminous cepheids known and it is the brightest one, after Polaris, in the sky, if we take apparent magnitude. I Car, where "I" is lower case L not i.
R Carinae (R Car)	December to August	3.9 – 10.5	Mira	307	R Carinae has to be observed with 3 different instruments if you want to cover its entire cycle: naked eye, binoculars, and telescope.

Last Steps

Keep observing!

Please make an observation of these stars at least once per month and submit your data as soon as you can.

Itching for a Bigger Challenge?

The AAVSO has many citizen science projects that range the gamut from introductory to advanced. Participants in the more advanced projects can even get their names published in professional journals. Our projects don't always involve making observations. Some involve programming, education & public outreach, data mining, data analysis and more. Contact us if you would like more information on these projects.

For More Information…

Visit www.aavso.org for more information on variable stars and how you can contribute to more citizen science projects. We also have a complete manual and curriculum about variable stars called *Variable Star Astronomy (VSA).* It is available at: http://www.aavso.org/education/vsa/

Special Thanks…

The following participants of the Citizen Sky "Southern Gems" team contributed to this 10-Star Southern Tutorial:

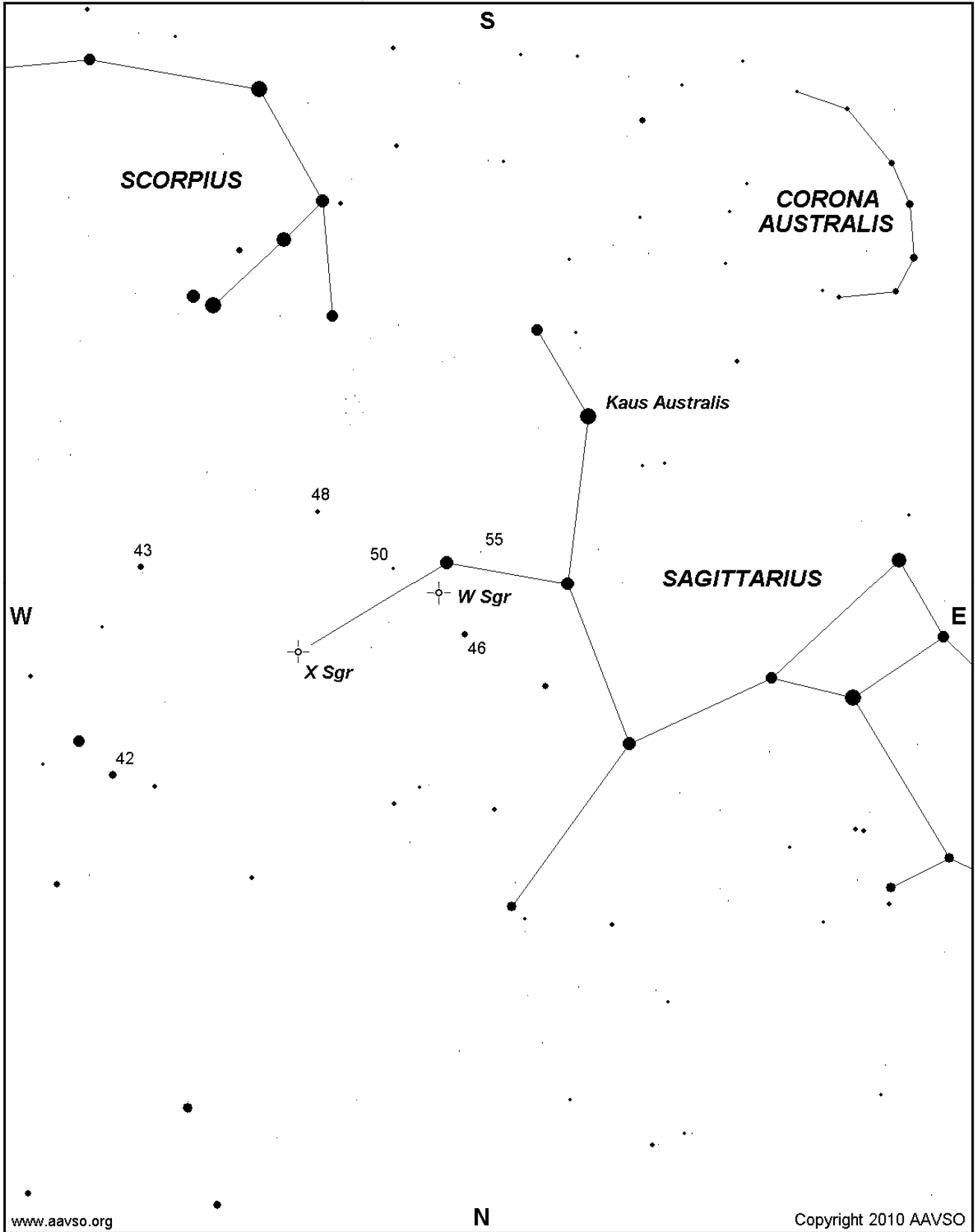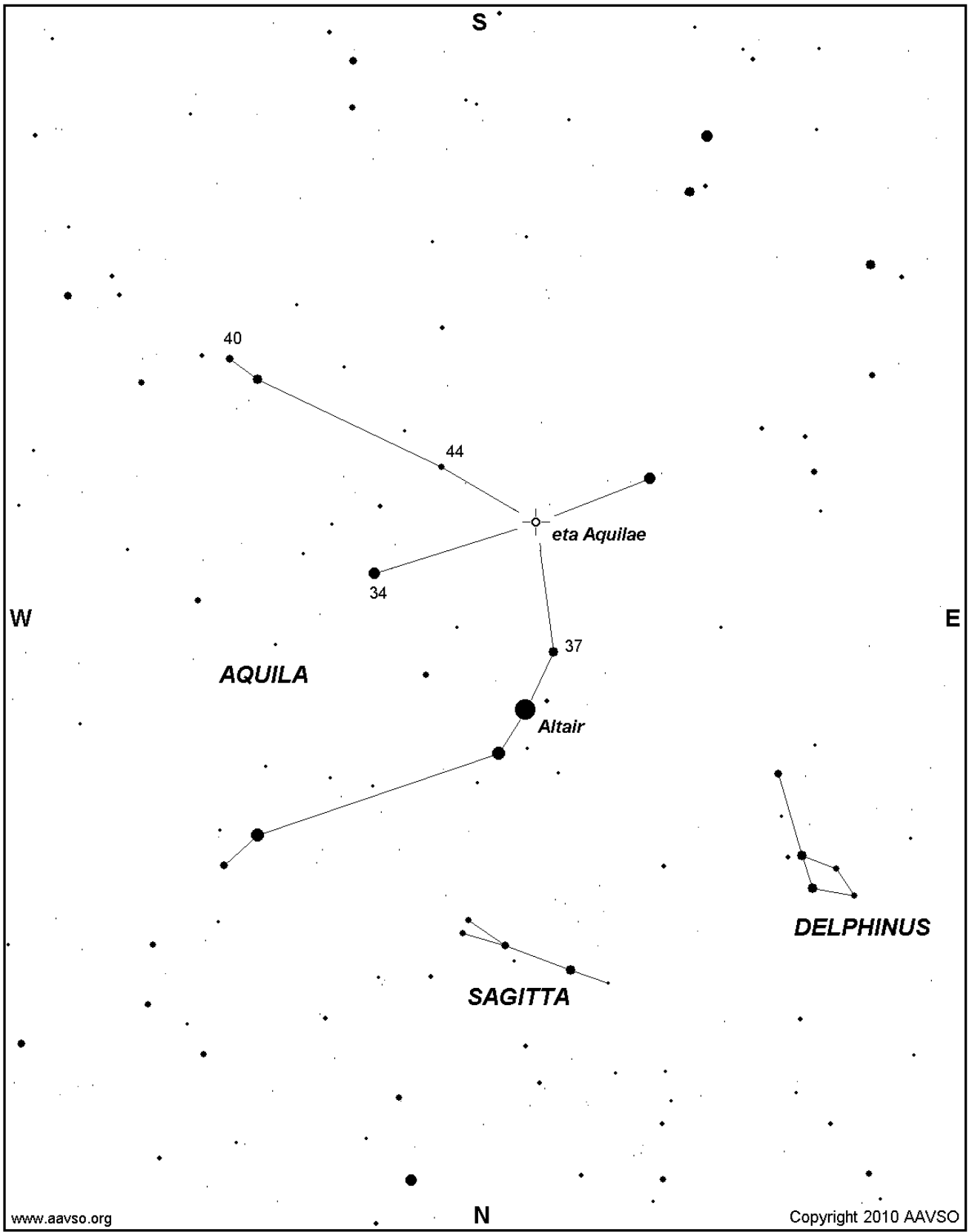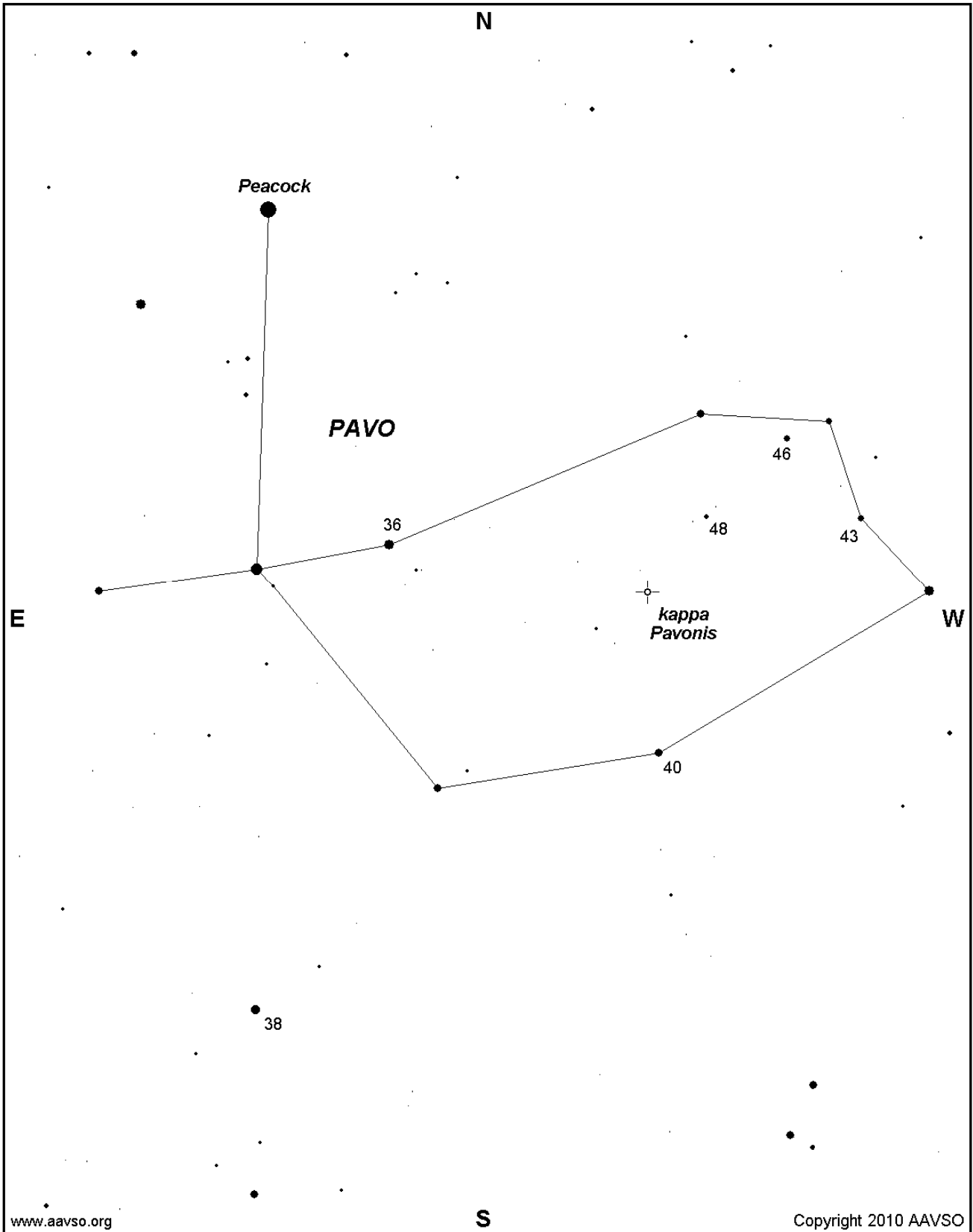|		
Joan Chamberlin	Sebastian Otero	David Benn
Julio Vannini	Jonatas C. Ramos	Aaron Price
Donna Burton	Marcelo Mojica Gundlach	Thilina Heenatigala
Marcio Malacarne	Mponda Malozo	Alan Plummer
Marcelo Souza	P.J. Goldfinger	

Star Chart for W Sagittarii and X Sagittarii

S

SCORPIUS

CORONA
AUSTRALIS

Kaus Australis

48

43

50

55

W Sgr

46

SAGITTARIUS

X Sgr

42

W

E

N

Star Chart for eta Aquilae

S

40

44

eta Aquilae

34

W

E

37

AQUILA

Altair

DELPHINUS

SAGITTA

N

Star Chart for kappa Pavonis

N

Peacock

PAVO

46

36

48

43

E

W

kappa
Pavonis

40

38

S

Star Chart for zeta Phoenicis

N

Ankaa

46

39

42

E

37

W

PHOENIX

ERIDANUS

zeta
Phoenicis

44

Achernar

TUCANA

S
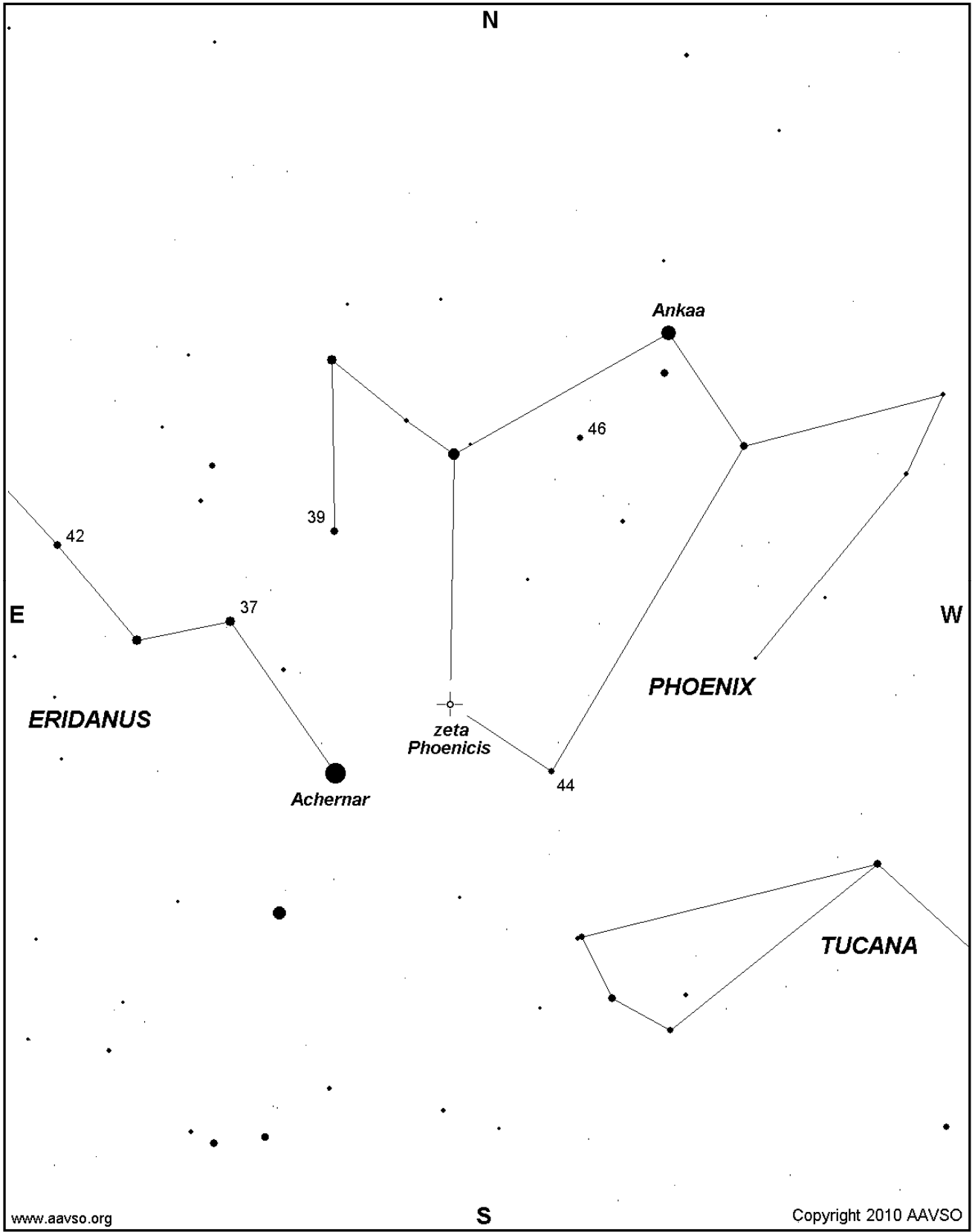
Chart for I Car, R Car, bet Dor and V Pup

VELA

PUPPIS

52

48

35

42

V Pup

46

41

45

I Car

CARINA

R Car 48

38

30

Canopus

33

VOLANS

40

PICTOR

36

43

bet Dor

DORADO

R Dor

South Pole

+

sigma Octantis

RETICULUM

Star Chart for R Carinae

N

E

W

S

45

71

69

59

66

82

I Carinae

76

48

56

96

R Car

94

64

99

104

87

85

Star Chart for R Doradus

N

RETICULUM

50

46

59

W

R Dor

E

55

57

68

alpha Reticuli

65

52

61
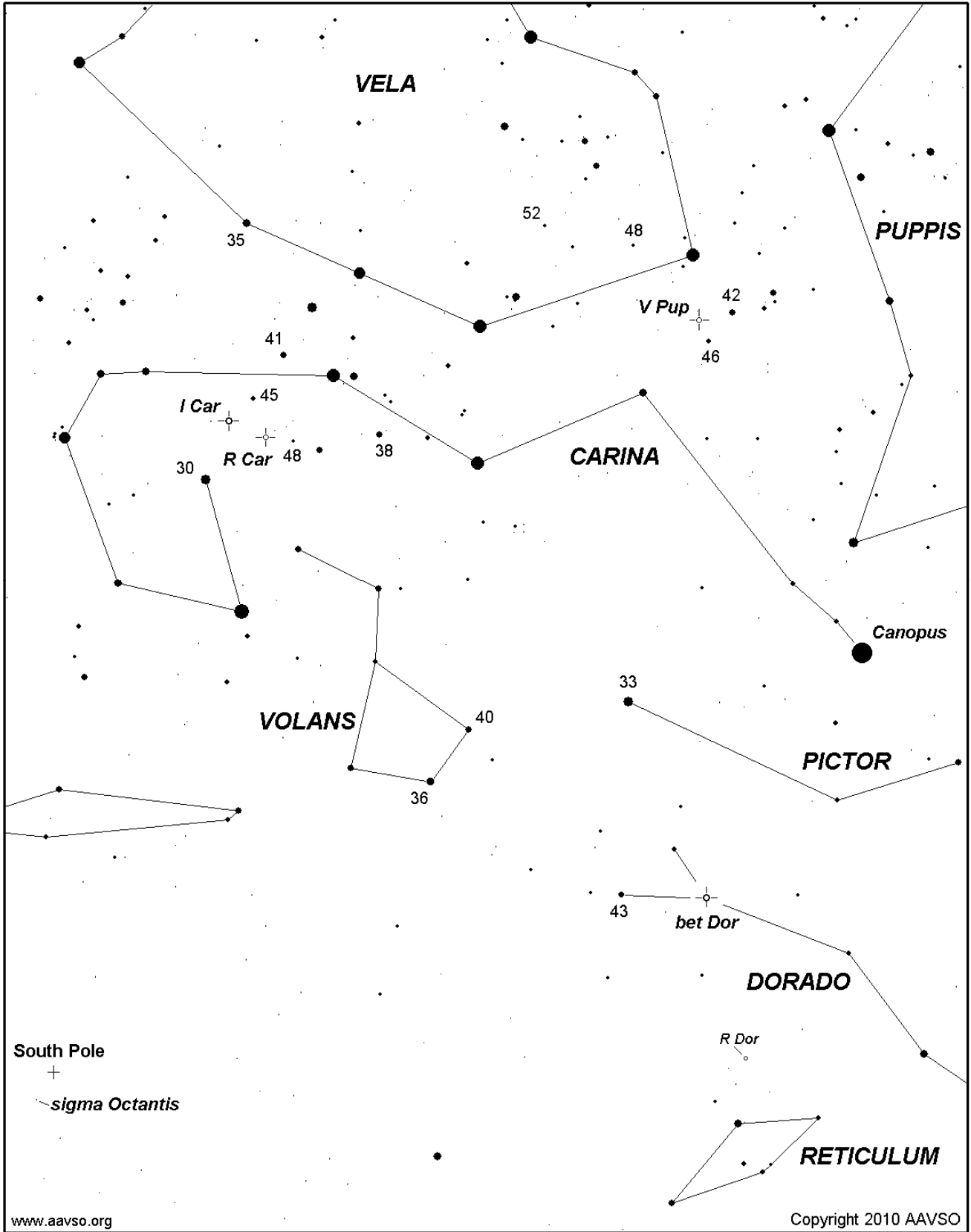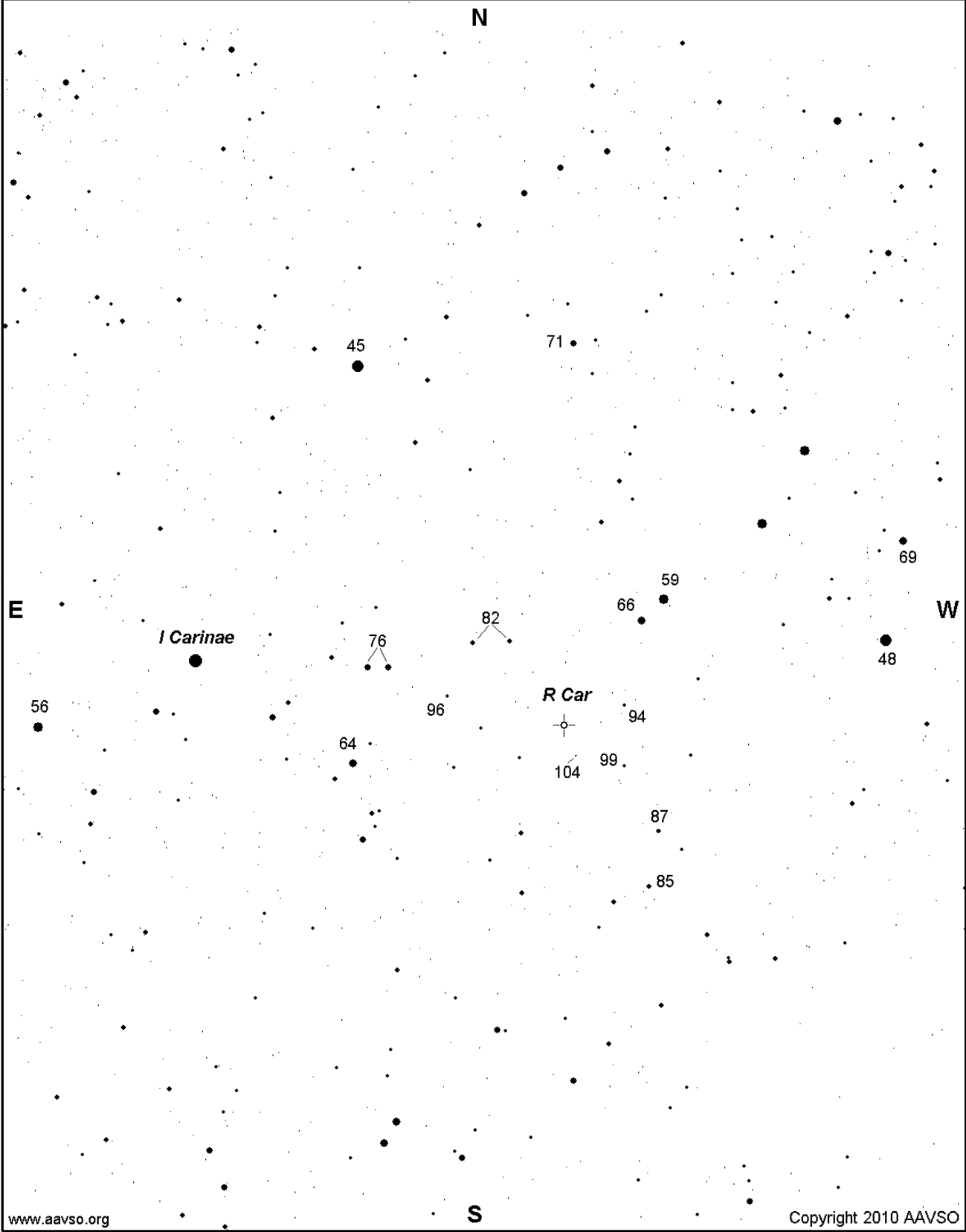
S
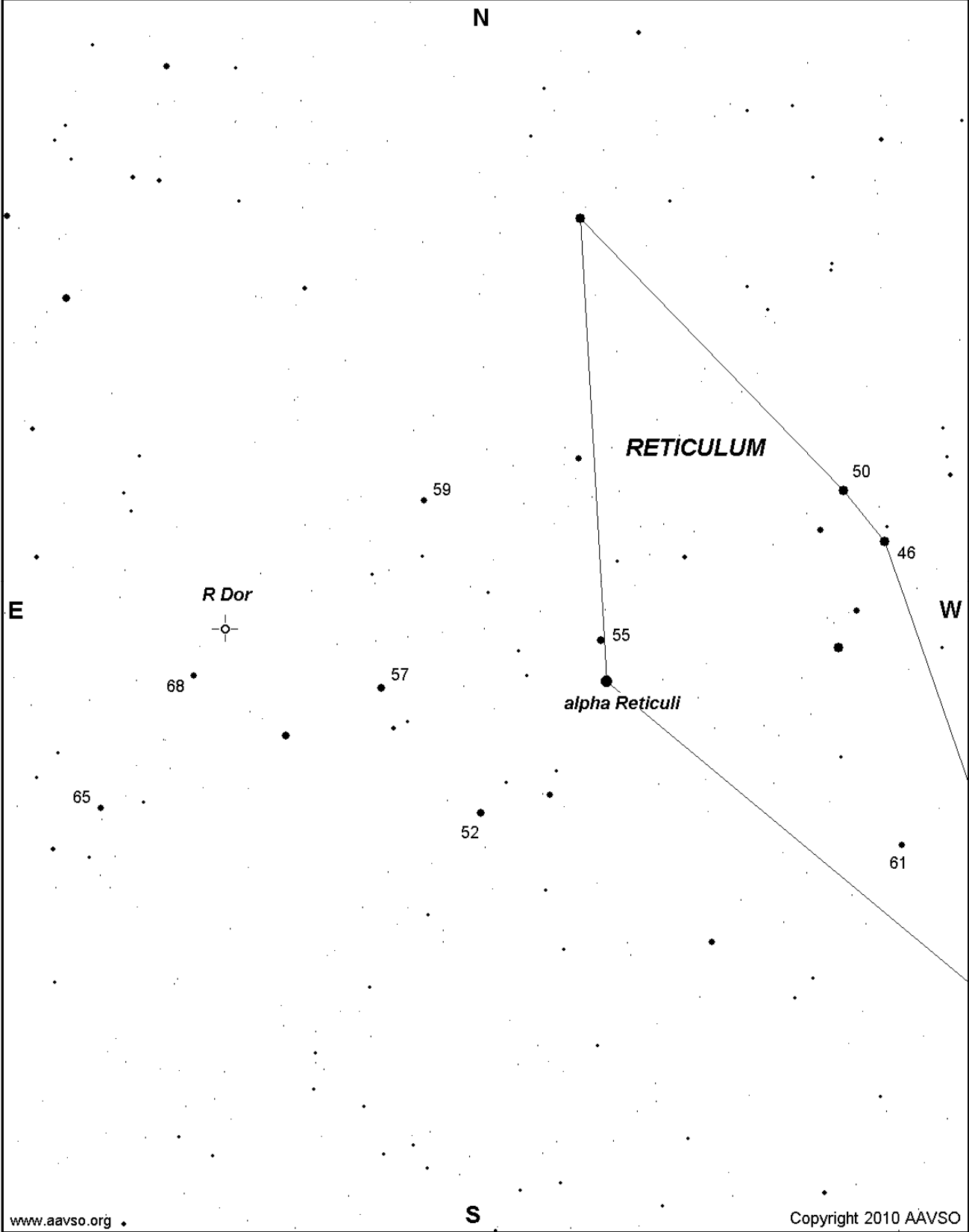
Star Chart for alpha Orionis