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Improving the Empirical Solar Wind Forecast

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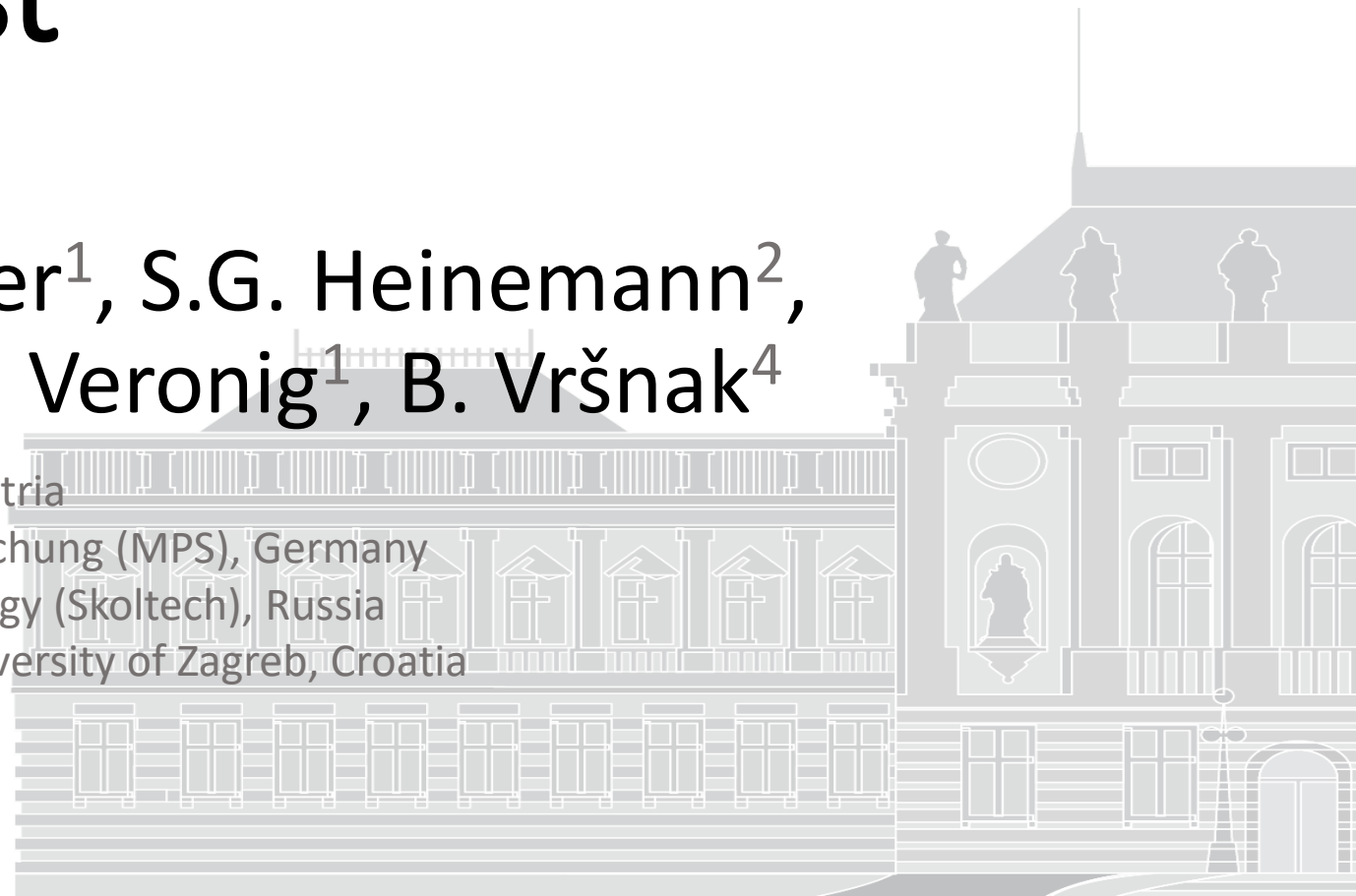


EGU General Assembly 2022

ESWF:

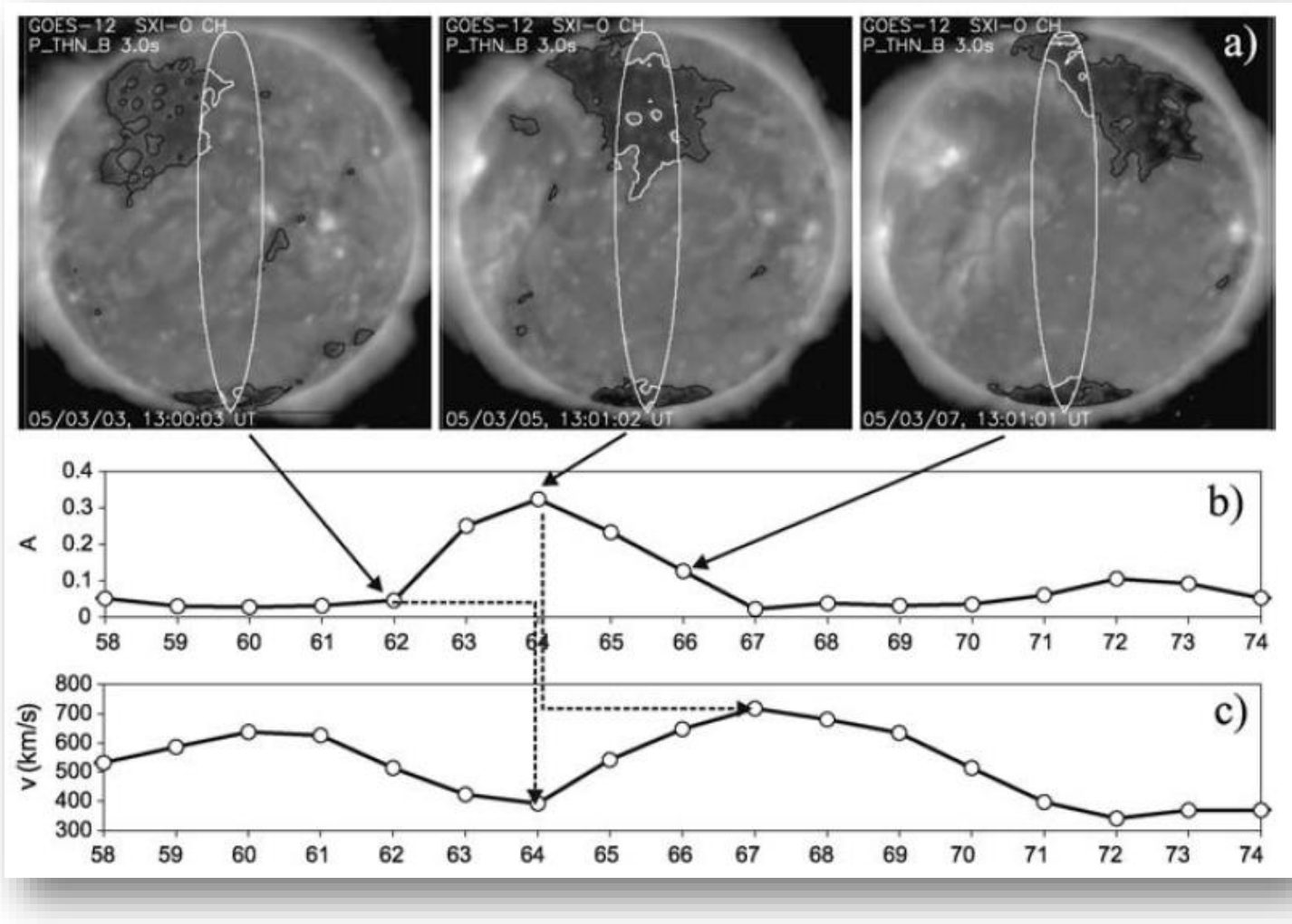
Empirical model for forecasting solar wind speed from relative Coronal Hole area (Vršnak et al., 2007; Rotter et al., 2015; Reiss et al., 2016)

$$v(t) = c_0 + c_1 * A(t')$$
$$t' = t + 4d$$

https://swe.uni-graz.at/index.php/services/solar-wind-forecast

Forecasting High Speed Streams (HSS):

measured profile: asymmetrical
model profile: symmetrical



Vršnak et al. (2007)

Improvement Steps

- ESWF 1.0 – Vršnak et al., 2007
  - Constant parameters c0, c1
  - $t' - t = 4\mathrm{d}$
- ESWF 2.0 – Rotter et al., 2015
  - Parameters c0, c1 re-evaluated every CR
  - $t' - t = 4\mathrm{d}$
- ESWF 3.0
  - PROP – algorithm:

$$t' - t = \frac{1AU}{v_{ESWF}(t)}$$

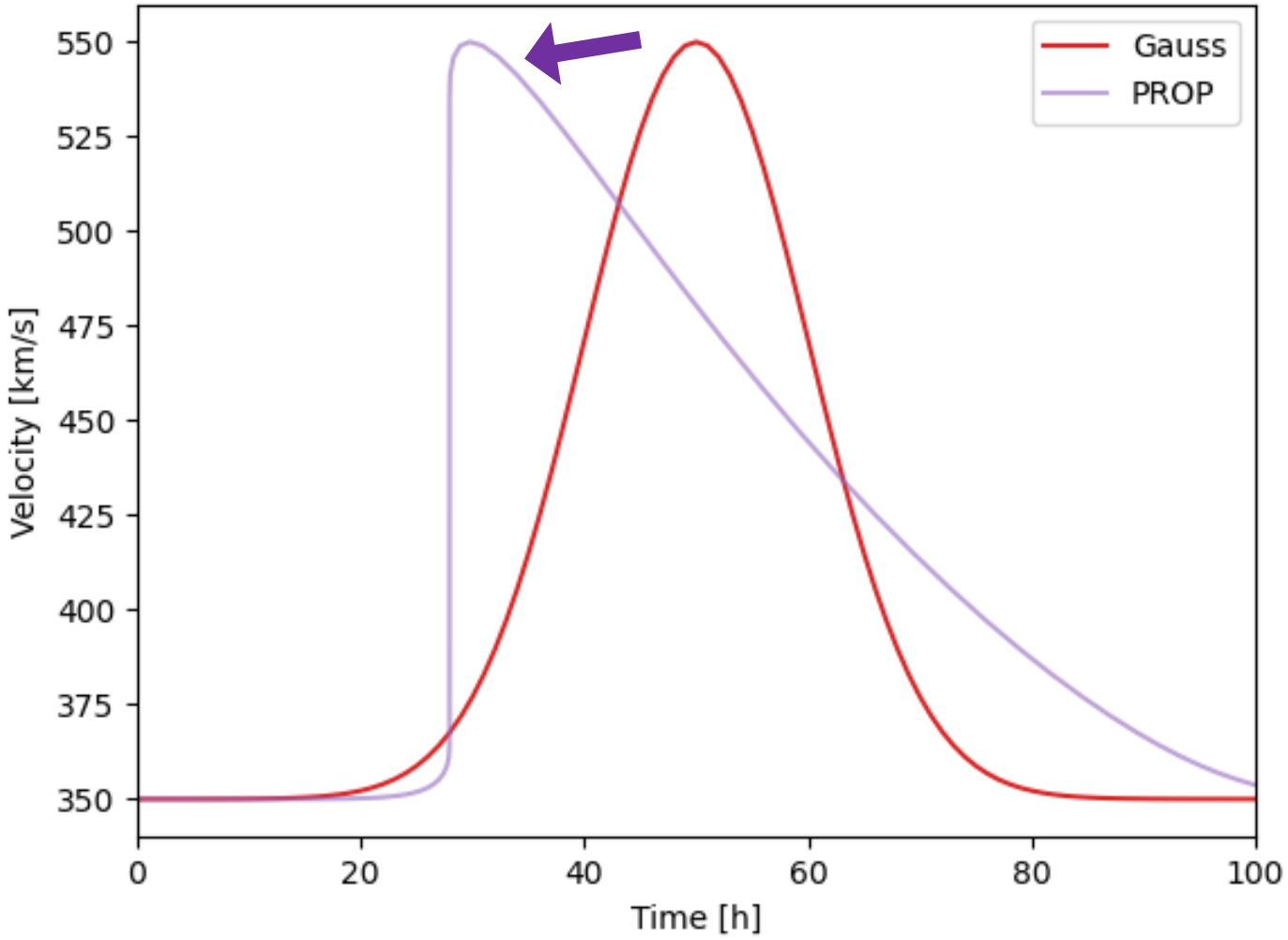
Improvement Steps

- ESWF 3.1
  - PILE – algorithm:

$$t' - t = \frac{1AU}{(v_{ESWF}(t) + v_{AMB})/2}$$

- ESWF 3.2
  - PILE – algorithm
  - Dynamic Thresholding (Heinemann et al., 2018)
  - Co-latitude information

PROP – Algorithm



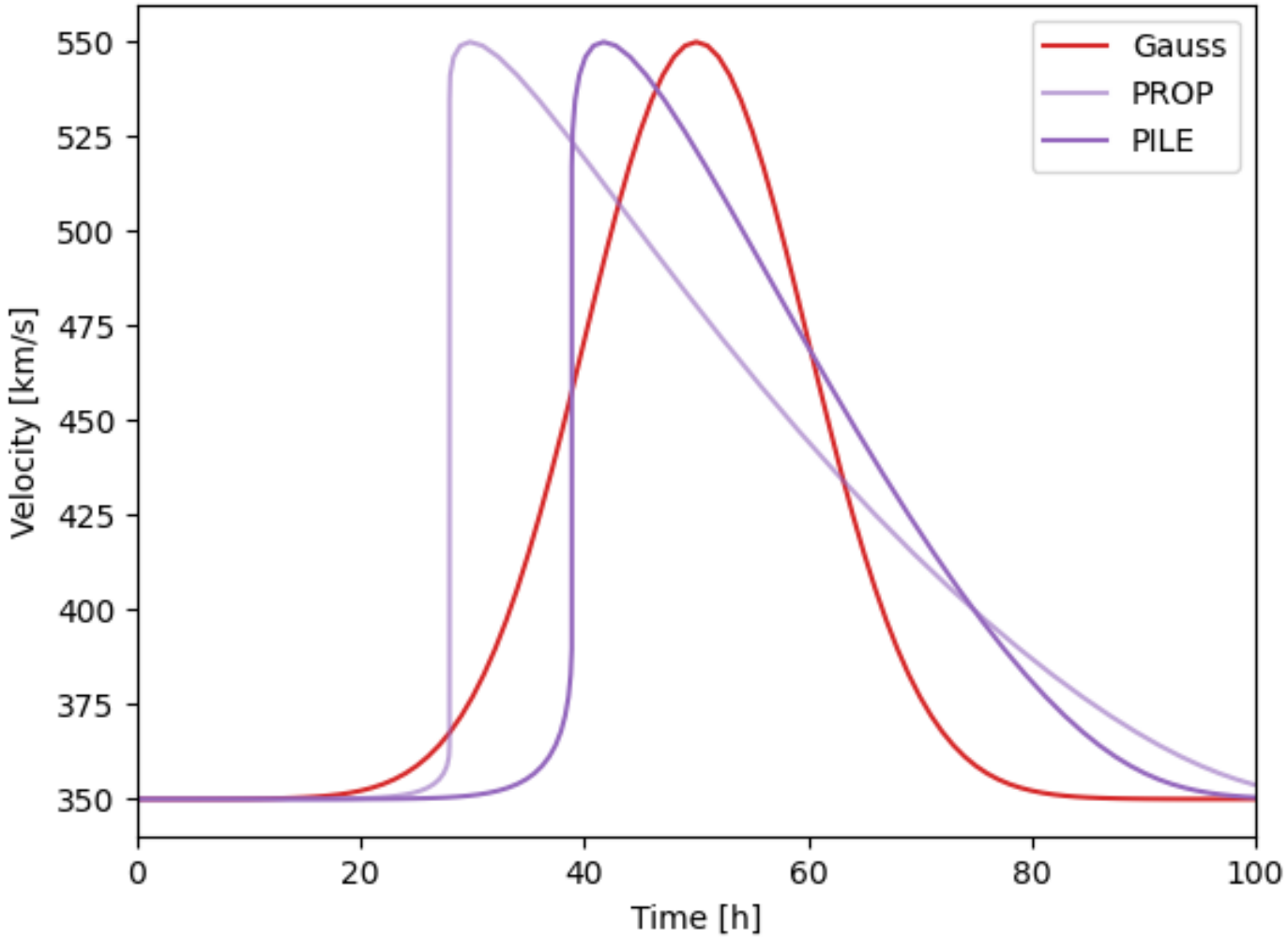
Propagation of velocities from the sun to 1AU

$$t' - t = \frac{1AU}{v_{ESWF}}$$

-> Asymmetric Profile

PILE – Algorithm

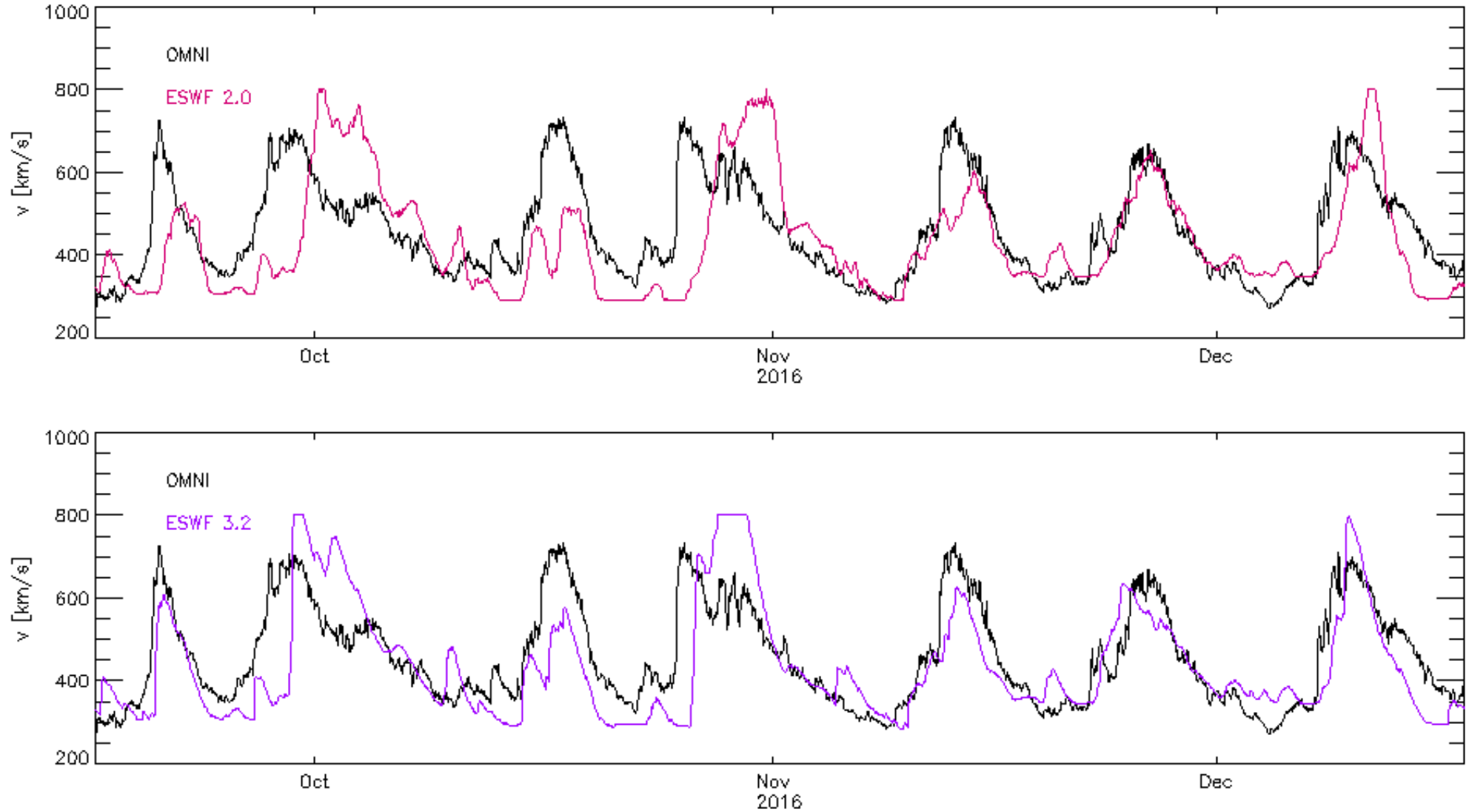
Less aggressive!



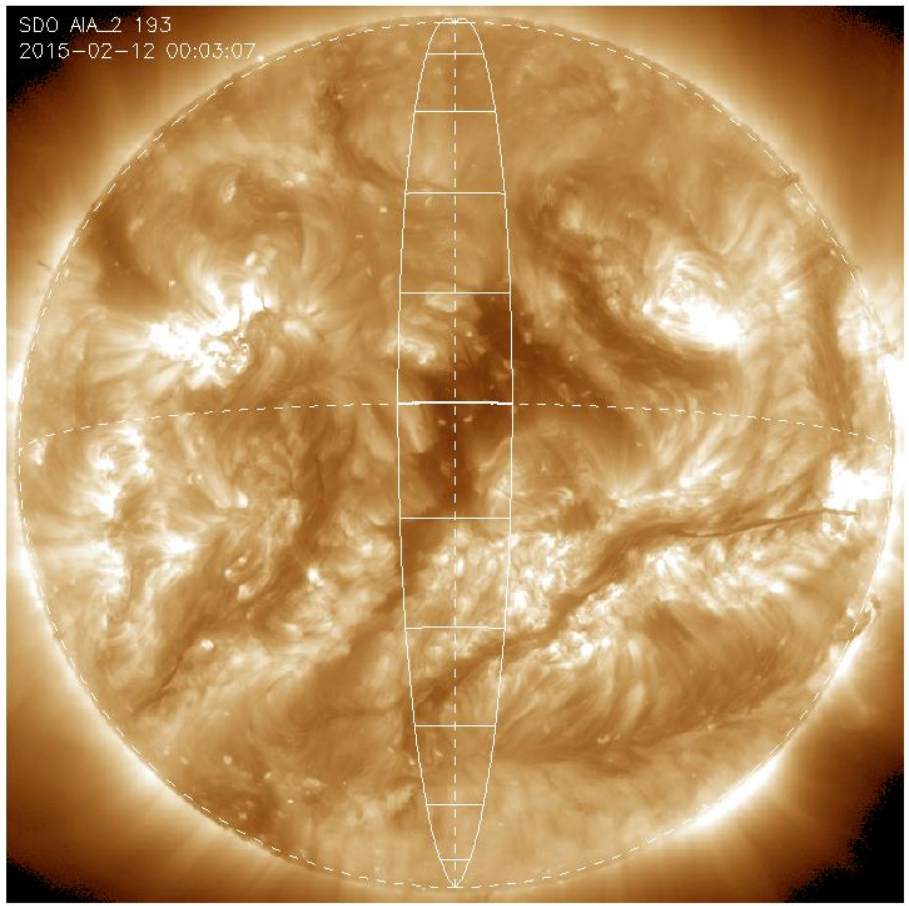
Propagation of velocities from the sun to 1AU

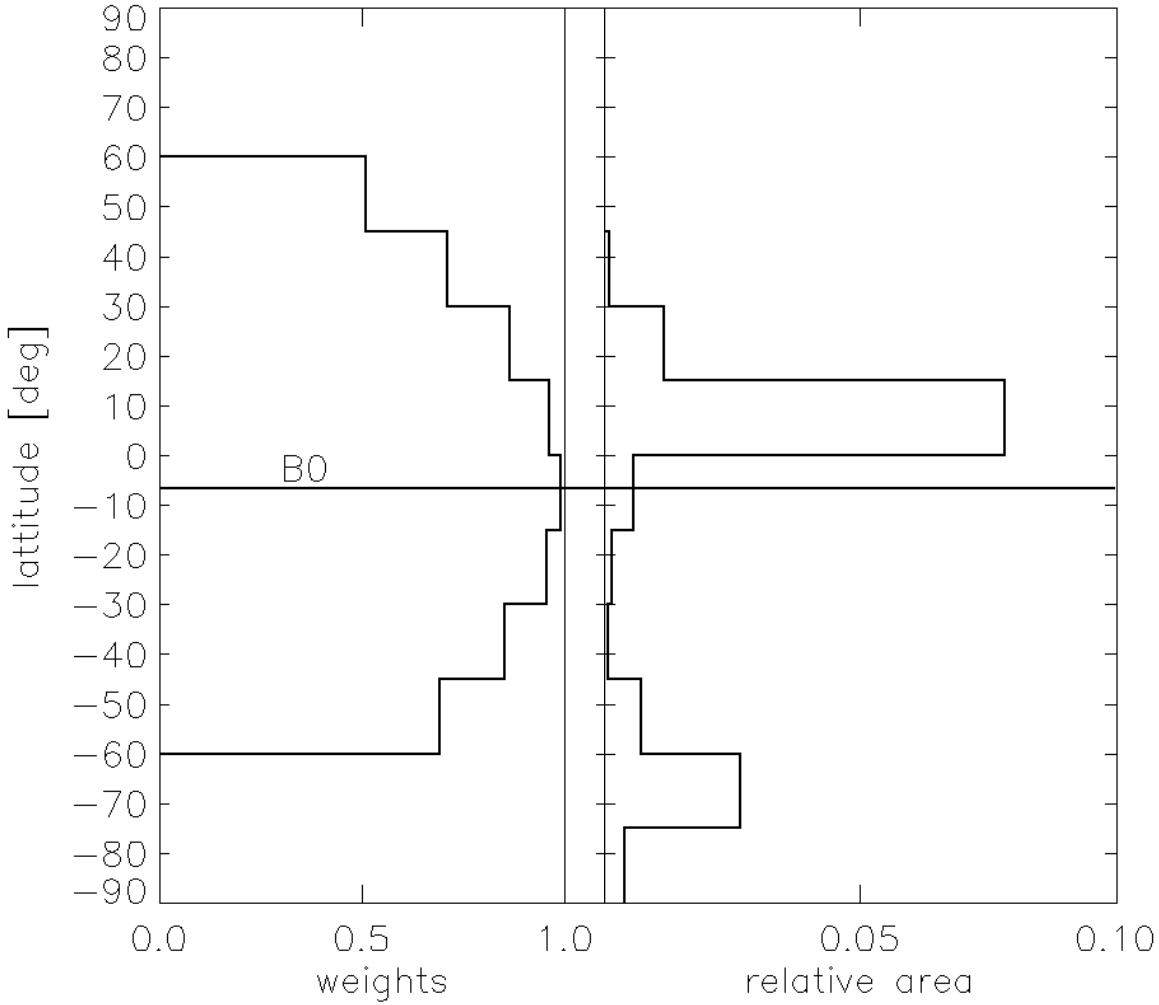
$$t' - t = \frac{1AU}{(v_{ESWF}(t) + v_{AMB})/2}$$

-> Slowed down by ambient SW

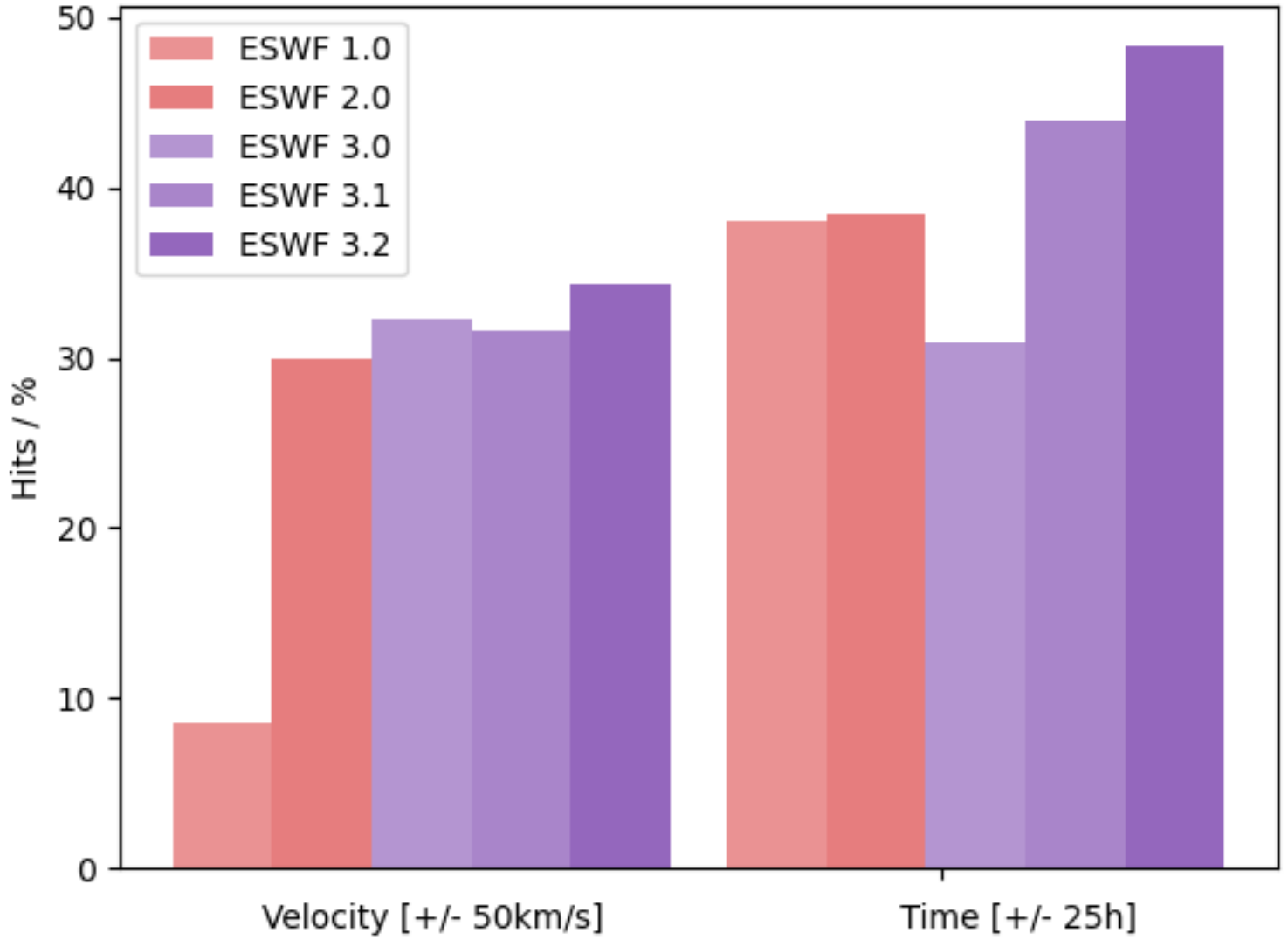

1000
800
600
400
200
v [km/s]
OMNI
ESWF 2.0
Oct
Nov
2016
Dec
1000
800
600
400
200
v [km/s]
OMNI
ESWF 3.2
Oct
Nov
2016
Dec

Co-latitude Information

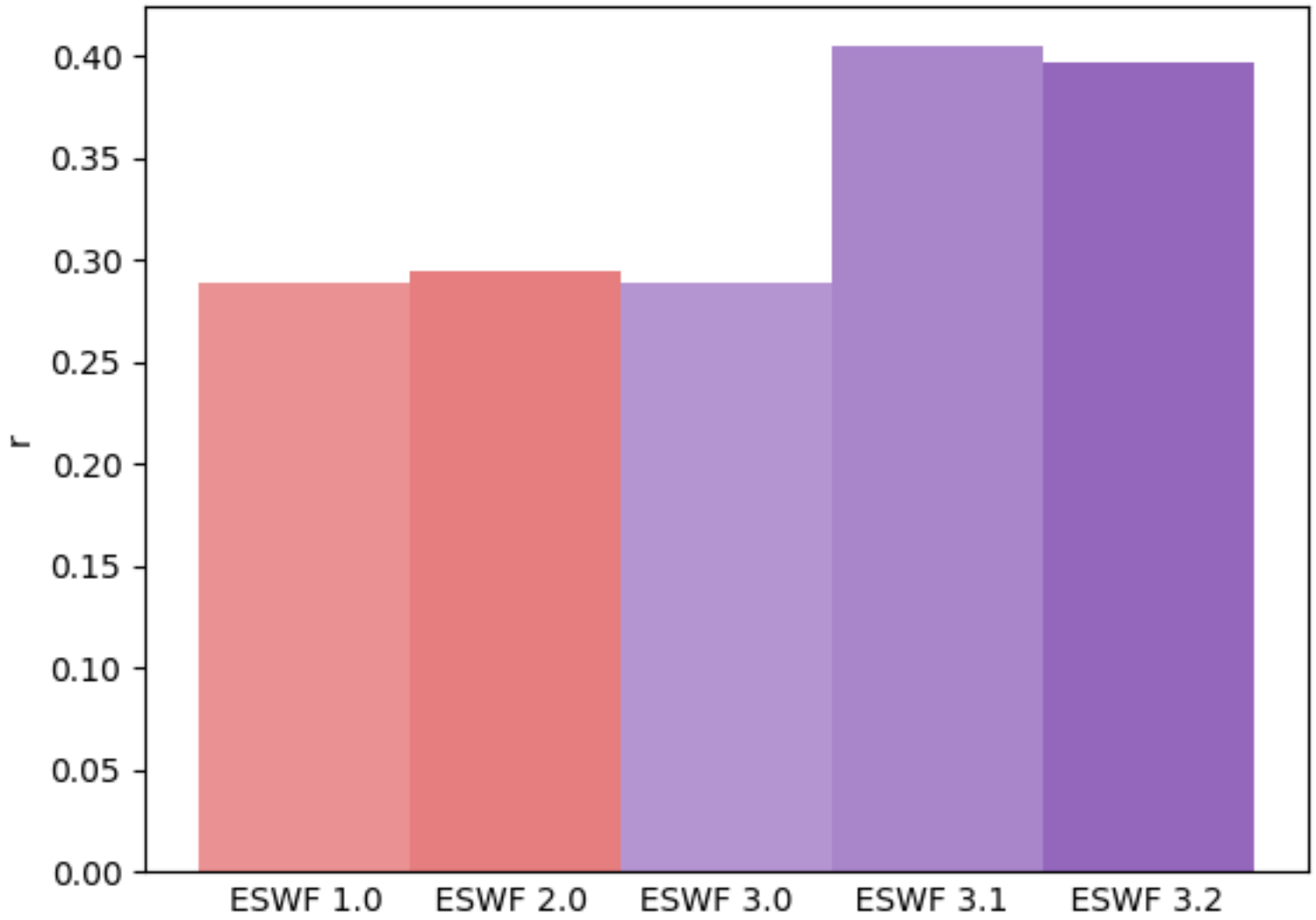




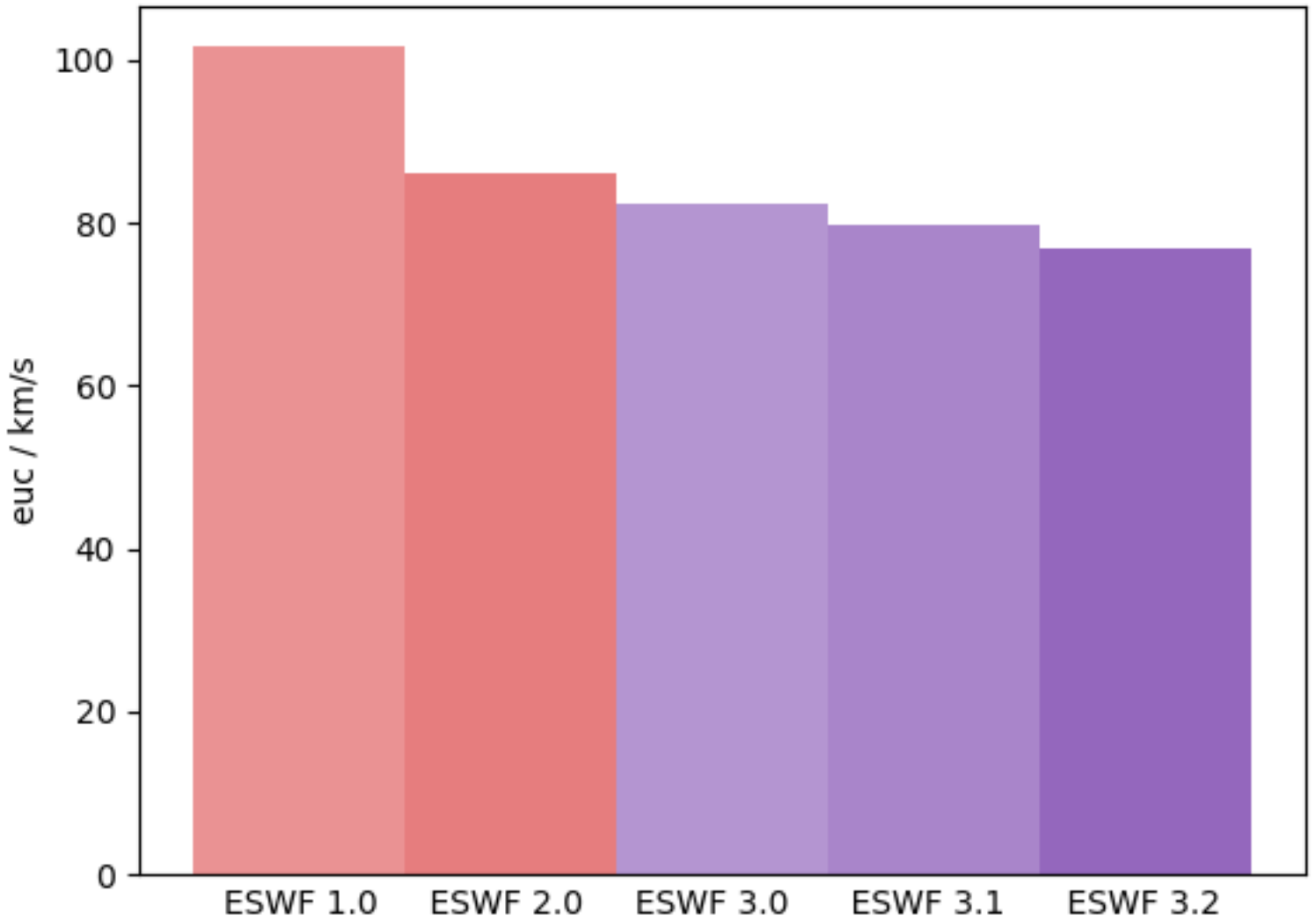
Hit & Miss


ESWF 1.0
ESWF 2.0
ESWF 3.0
ESWF 3.1
ESWF 3.2
Hits / %
0
10
20
30
40
50
Velocity [+/- 50km/s]
Time [+/- 25h]

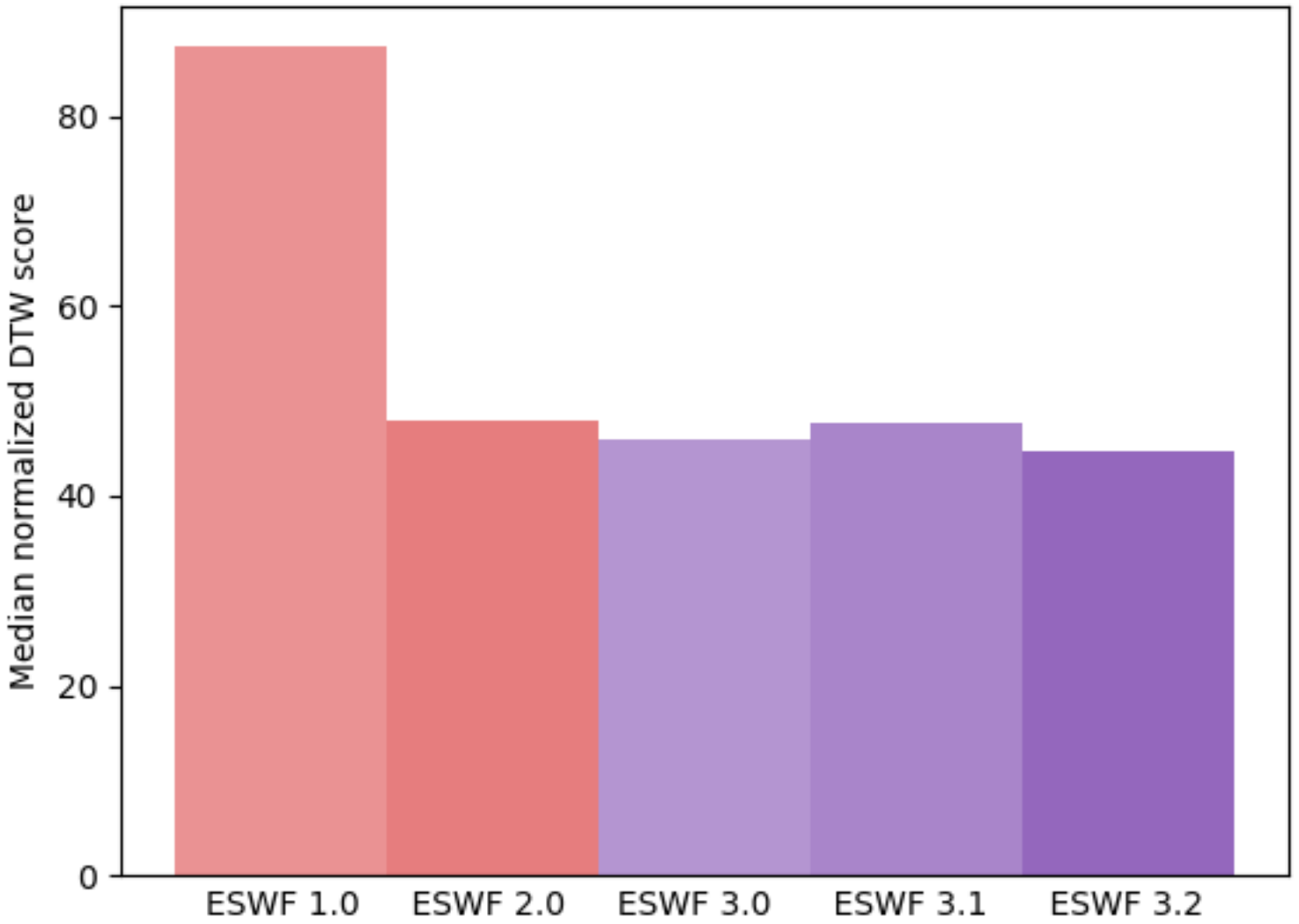
Pearson Correlation



Euclidian Distance



Dynamic Time Warping Score



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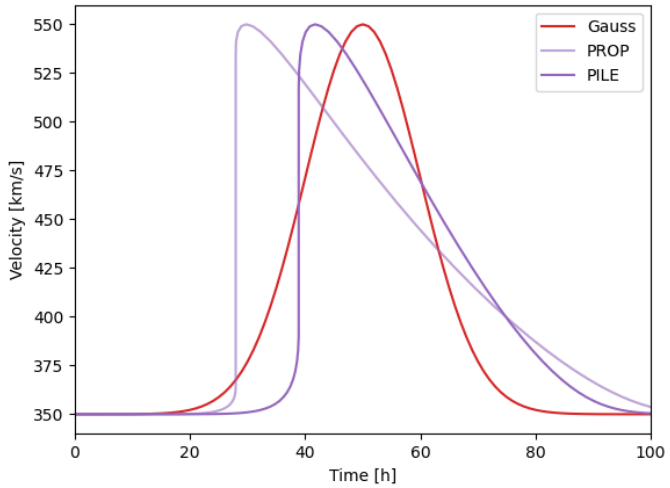
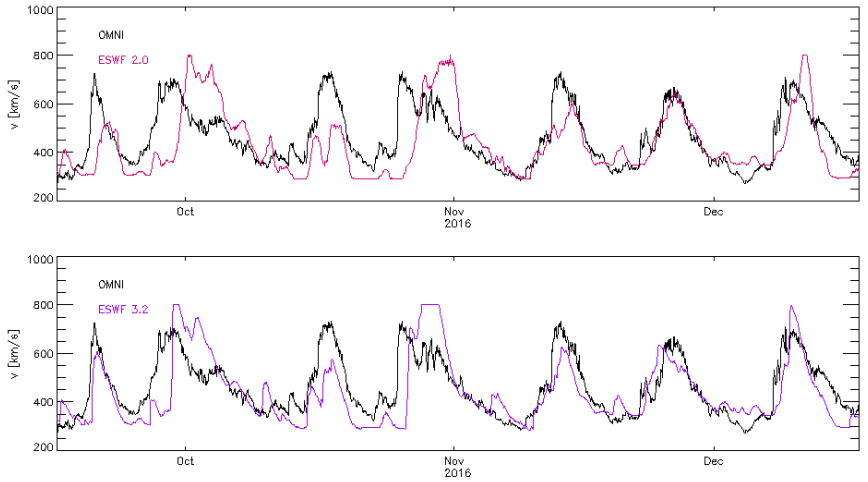
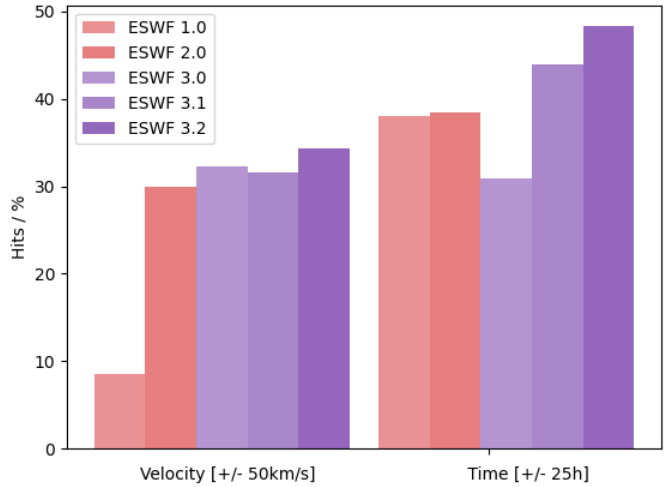
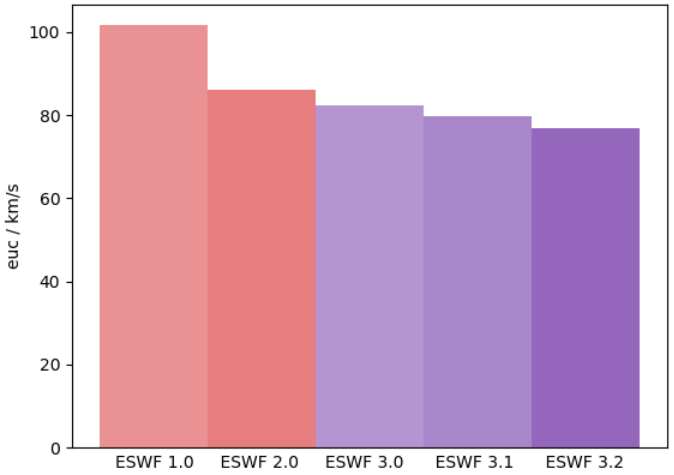
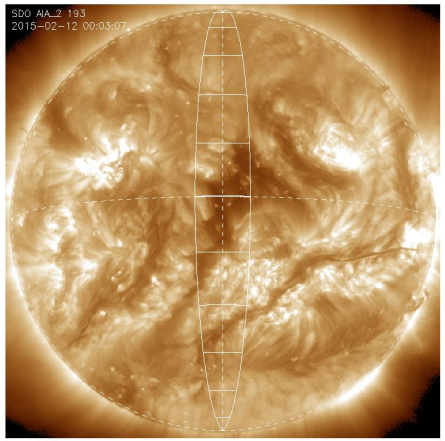

Gauss
PROP
PILE
Velocity [km/s]
Time [h]

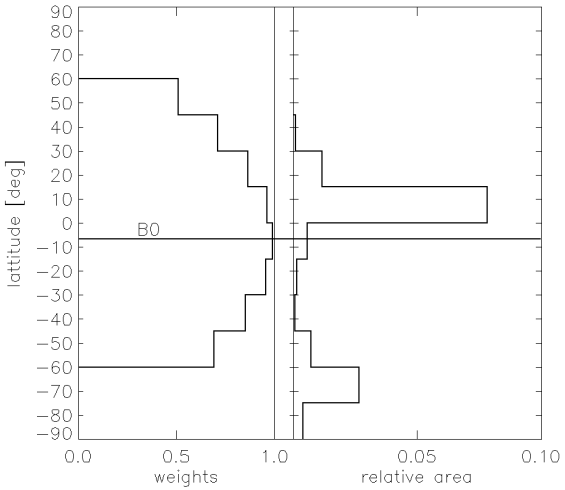

OMNI
ESWF 2.0
OMNI
ESWF 3.2
v [km/s]
Oct
Nov
2016
Dec

Thank You!


ESWF 1.0
ESWF 2.0
ESWF 3.0
ESWF 3.1
ESWF 3.2
Hits / %
Velocity [+/- 50km/s]
Time [+/- 25h]


euc / km/s
ESWF 1.0
ESWF 2.0
ESWF 3.0
ESWF 3.1
ESWF 3.2


SDO AIA_2 193
2015-02-12 00:03:07


B0
lattitude [deg]
weights
relative area