

Diagramas de Taylor y Sailor



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¿Quién soy?



Introducción



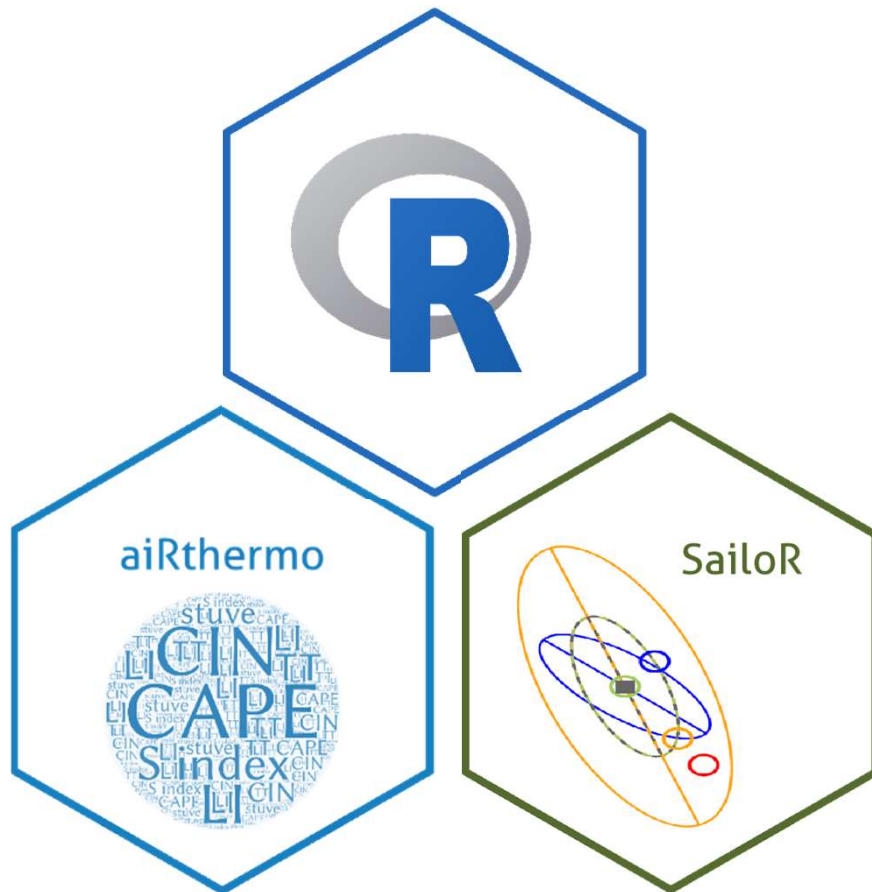
EOLO

Meteorología, Clima y Medio Ambiente



- Equipo interdisciplinar
- Líneas de investigación
 - Ciclo del agua en la atmosfera
 - Energía Eólica
 - Energía Marina

Introducción



■ **aiRthermo**

Cálculos y visualización de
termodinámica atmosférica

■ **SailoR**

Diagrama de validación para variables
bidimensionales

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Taylor



Resumir múltiples aspectos del funcionamiento de los modelos en un único diagrama

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 106, NO. D7, PAGES 7183–7192, APRIL 16, 2001

Summarizing multiple aspects of model performance in a single diagram

Karl E. Taylor

Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory
Livermore, California

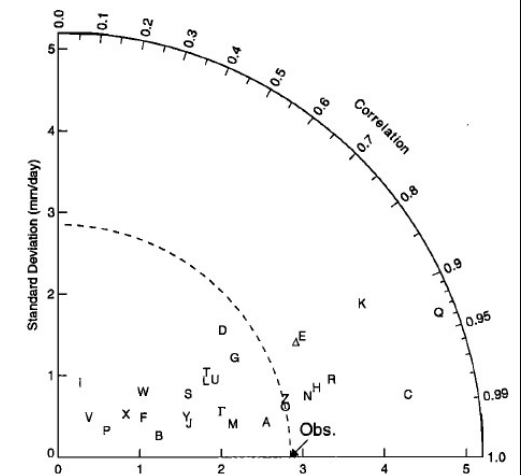


Figure 3. Pattern statistics describing the climatological annual cycle of precipitation over India simulated by 28 models compared with the observed [Parthasarathy *et al.*, 1994]. To simplify the plot, the isolines indicating correlation, standard deviation, and RMS error have been omitted.

Taylor



R^2 : Coeficiente de correlación entre las observaciones y de las simulaciones
 SD : Desviación Estandar de las observaciones y de las simulaciones
 $RMSE$: RMSE centrado entre las observaciones y las simulaciones



Teorema del coseno

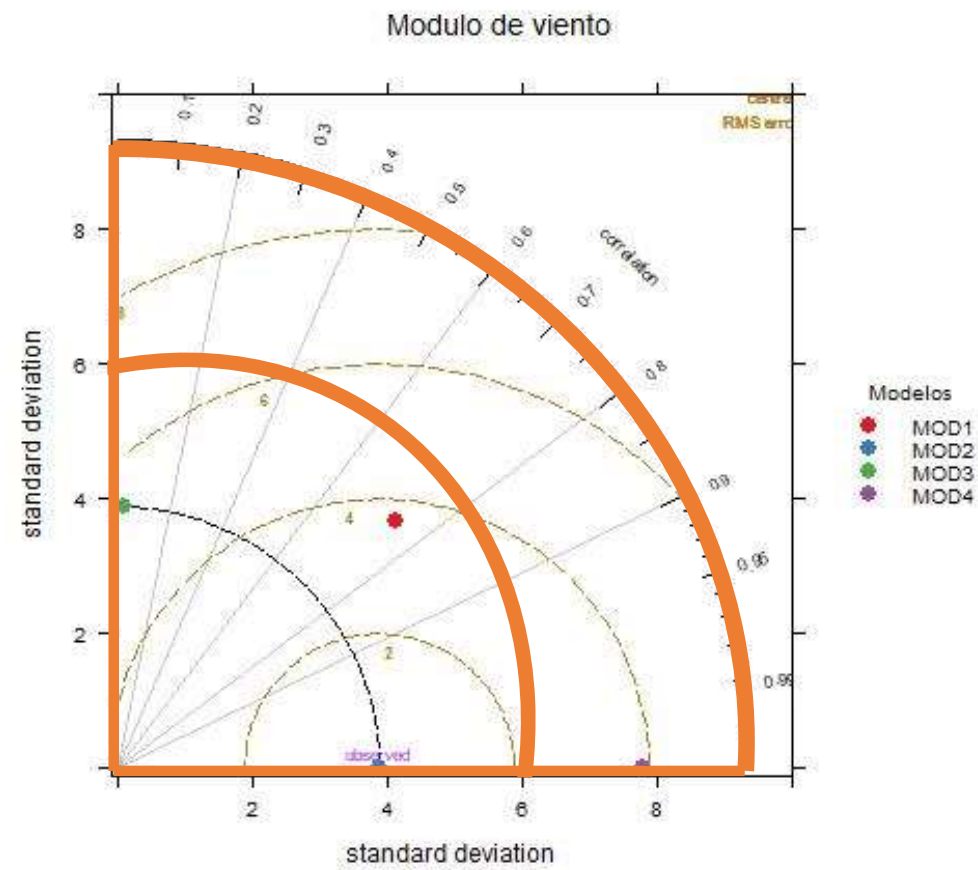


$$RMSE = SD_{Obs}^2 + SD_{Sim}^2 - 2SD_{Obs}SD_{Sim}R^2$$

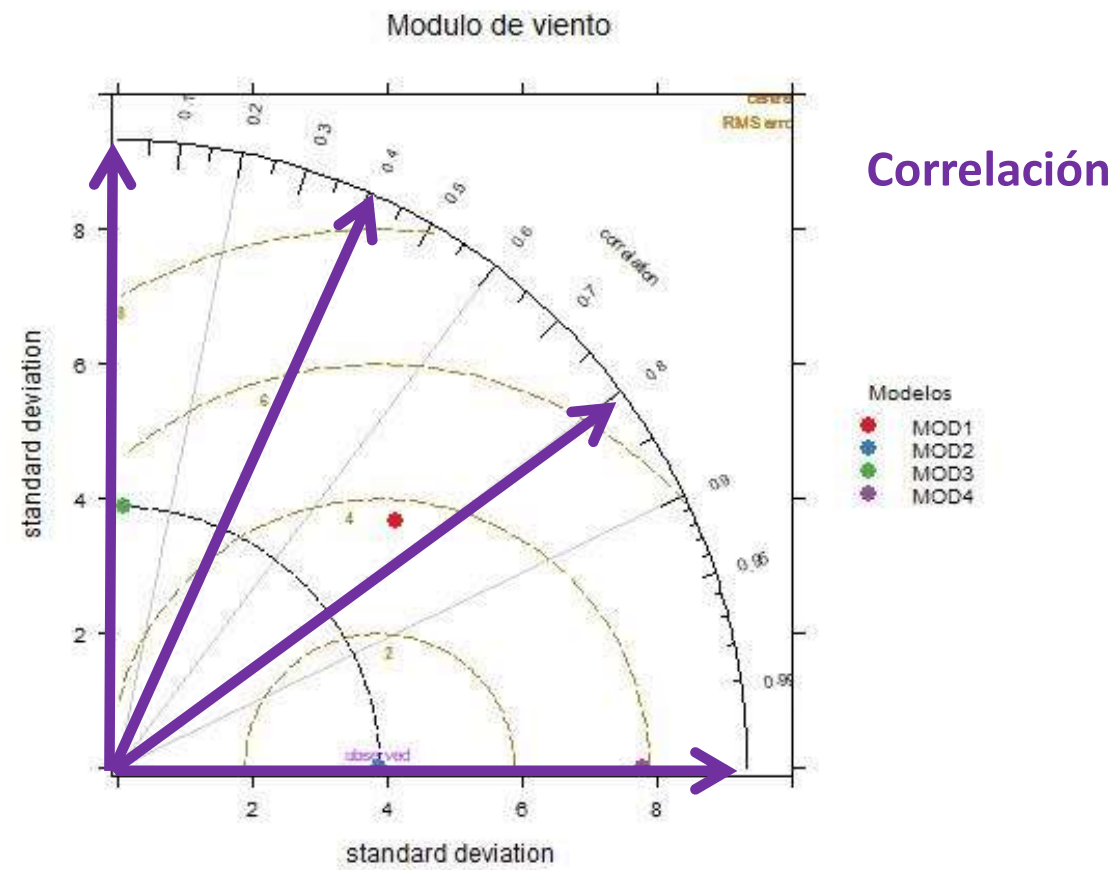
Taylor



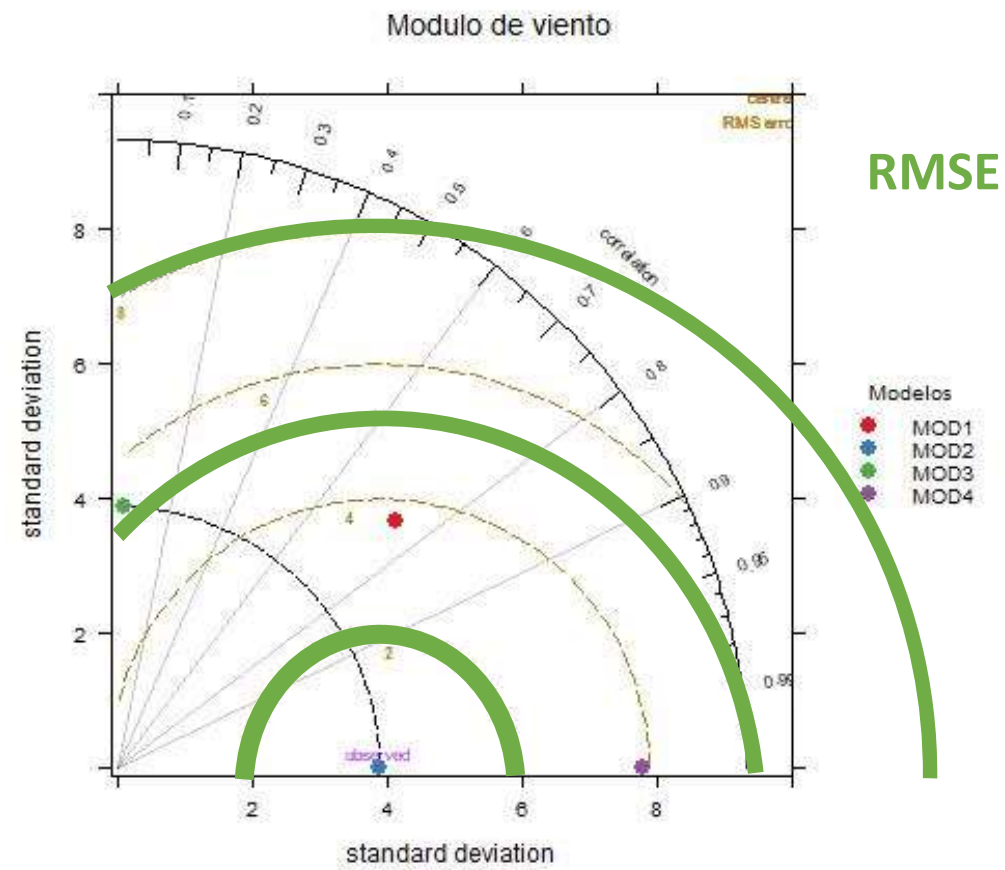
SD



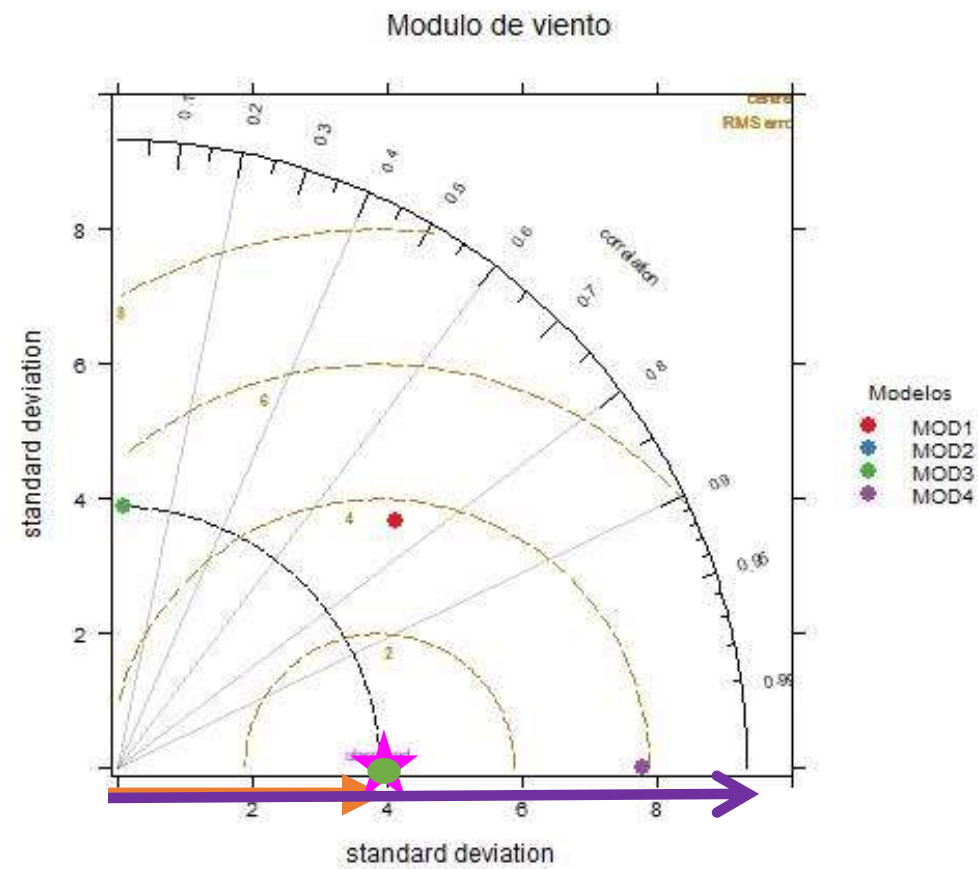
Taylor



Taylor



RMSE



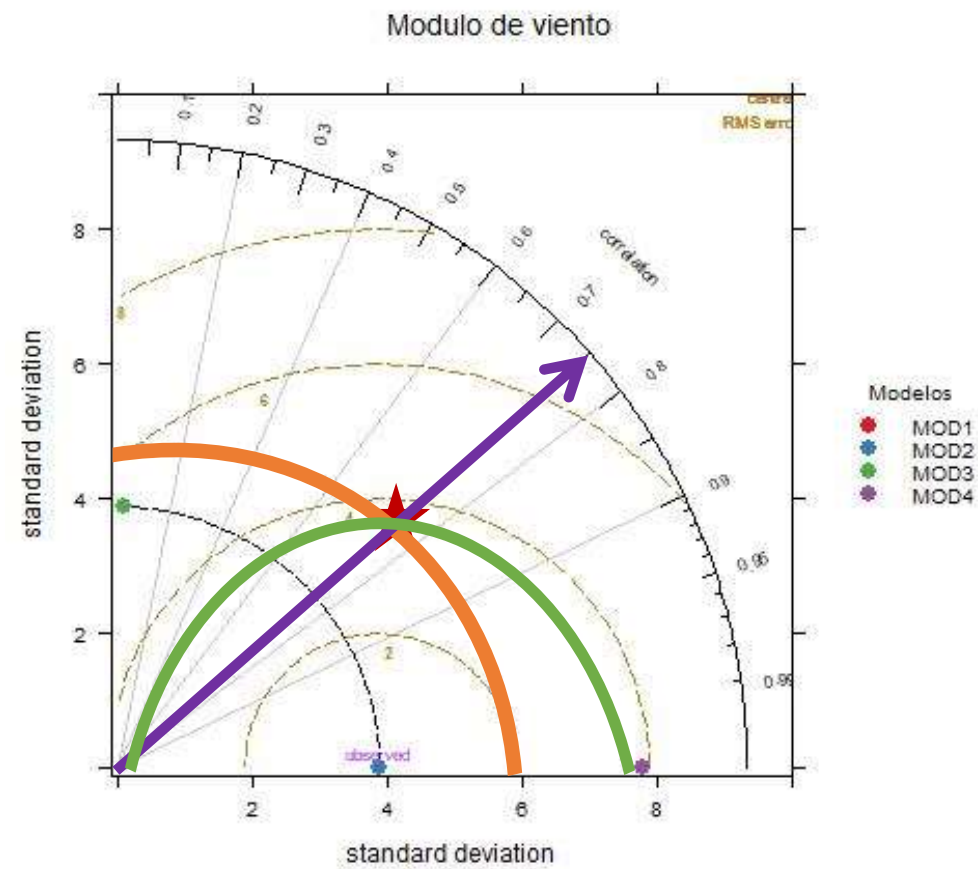
Taylor



SD

Correlación

RMSE



Taylor



```
1
2 #Directorio de trabajo
3
4 setwd("E:/UPVEHU/2021/2021_09_29_R_Ladies/")
5
6 #Librerias necesarias instalar
7 #install.packages("SailoR")#Sailor
8 #install.packages("plotrix") #Taylor
9 #install.packages("openair") #Taylor
10 #install.packages("hydroGOF") #RMSE
11
12
13 #Cargar librerias
14 library("SailoR")
15 #library("plotrix") #Taylor
16 library("openair") #Taylor
17 library("hydroGOF") #RMSE
18
```


Taylor



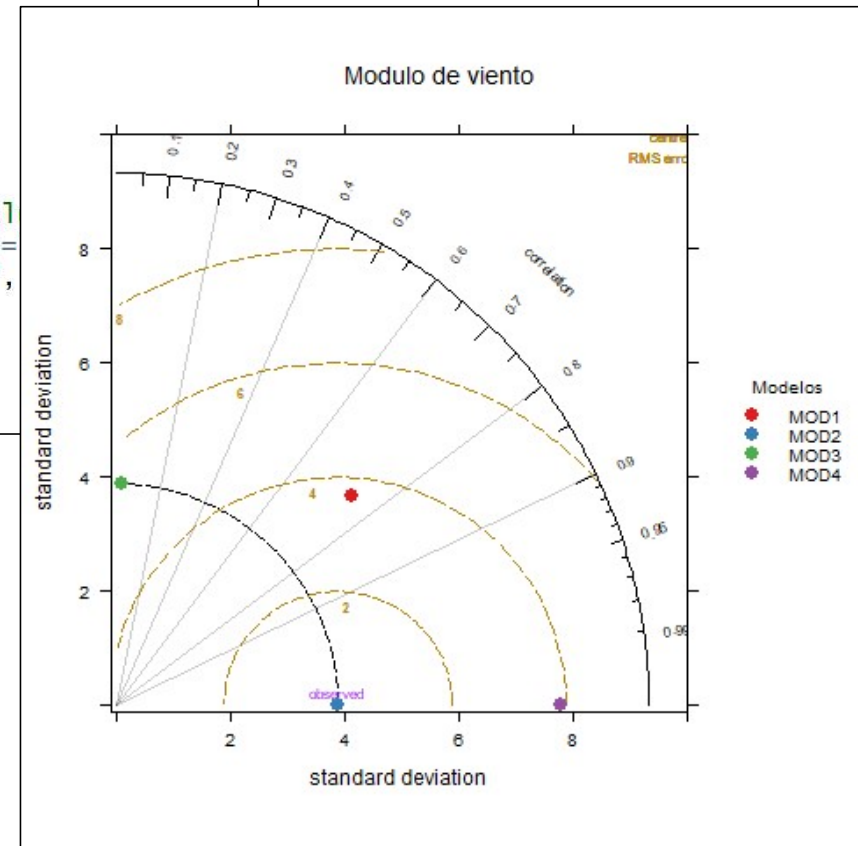
```
20 #Diagrama de Taylor
21 #~~~~~
22 # Cargar datos de velocidad de viento observados
23 # y de 4 modelos diferentes
24 load("data_vel.RData")
25
26 #Clase
27 class(data_vel)
28
29 #Forma de los datos
30 head(data_vel)
31
32 #Resumen de los datos
33 summary(data_vel)
34
```

```
> #Clase
> class(data_vel)
[1] "data.frame"
> #Forma de los datos
> head(data_vel)
  obs_name obs_value mod_name mod_value
1      REF  5.199540   MOD1    13.41392
2      REF  9.265842   MOD1    17.52590
3      REF 11.119187   MOD1    19.43096
4      REF 13.809581   MOD1    22.13228
5      REF 12.444884   MOD1    20.65443
6      REF 13.328835   MOD1    21.52180
> #Resumen de los datos
> summary(data_vel)
obs_name      obs_value      mod_name      mod_value
REF :11680   Min.      : 0.1752   REF :    0   Min.      : 0.1752
MOD1:    0   1st Qu.: 4.7758   MOD1:2920   1st Qu.: 6.4889
MOD2:    0   Median : 7.8338   MOD2:2920   Median :10.7158
MOD3:    0   Mean    : 7.9581   MOD3:2920   Mean    :11.5823
MOD4:    0   3rd Qu.:11.1453   MOD4:2920   3rd Qu.:15.6133
                        Max.      :19.0443                        Max.      :38.0885
```


Taylor



```
34  
35 #Diagrama de Taylor  
36 TaylorDiagram(data_vel, obs = "obs_value",  
37               mod = "mod_value", group="mod_name",  
38               main="Modulo de viento",  
39               key.title="Modelos",  
40               xlim=c(-0.1,10),  
41               ylim=c(-0.1,10))  
42  
43 #Para guardar el gráfico  
44 jpeg("Taylor.jpg")  
45 TaylorDiagram(data_vel, obs = "obs_val",  
46               mod = "mod_value", group=  
47               main="Modulo de viento",  
48               key.title="Modelos",  
49               xlim=c(-0.1,10),  
50               ylim=c(-0.1,10))  
51 dev.off()  
52
```



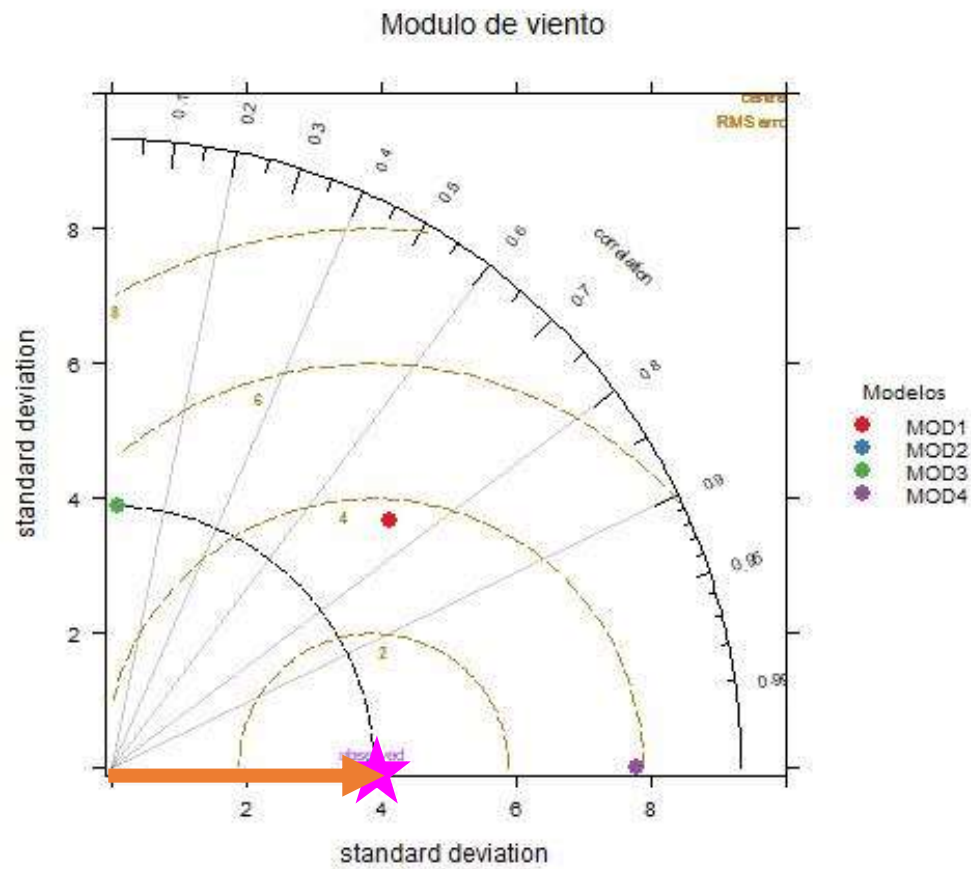
Taylor



```
53 #Estadísticos de la referencia y el modelo1
54 n1<-which(data_vel$mod_name=="MOD1")
55 OBS1<-data_vel[n1,"obs_value"]
56 MOD1<-data_vel[n1,"mod_value"]
57
58 #Desviación Estandar
59 sd(OBS1)
60 sd(MOD1)
61
62 #Correlación
63 cor(OBS1,MOD1)
64
65 #RMSE
66 rmse(OBS1,MOD1)
67
68 obs_mean<-mean(OBS1)
69 mod_mean<-mean(MOD1)
70 rmse(OBS1-obs_mean,MOD1-mod_mean)
71
```

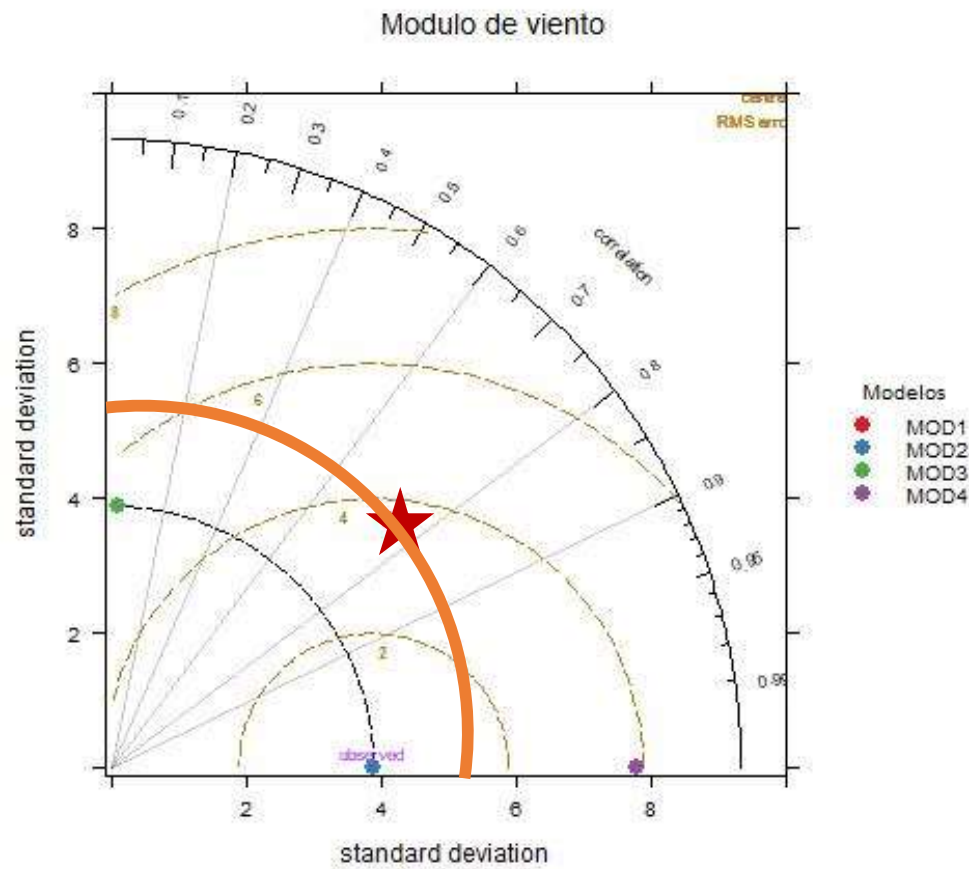
```
> #Desviación Estandar
> sd(OBS1)
[1] 3.887556
```

Taylor



```
> #Desviación Estandar  
> sd(OBS1)  
[1] 3.887556
```

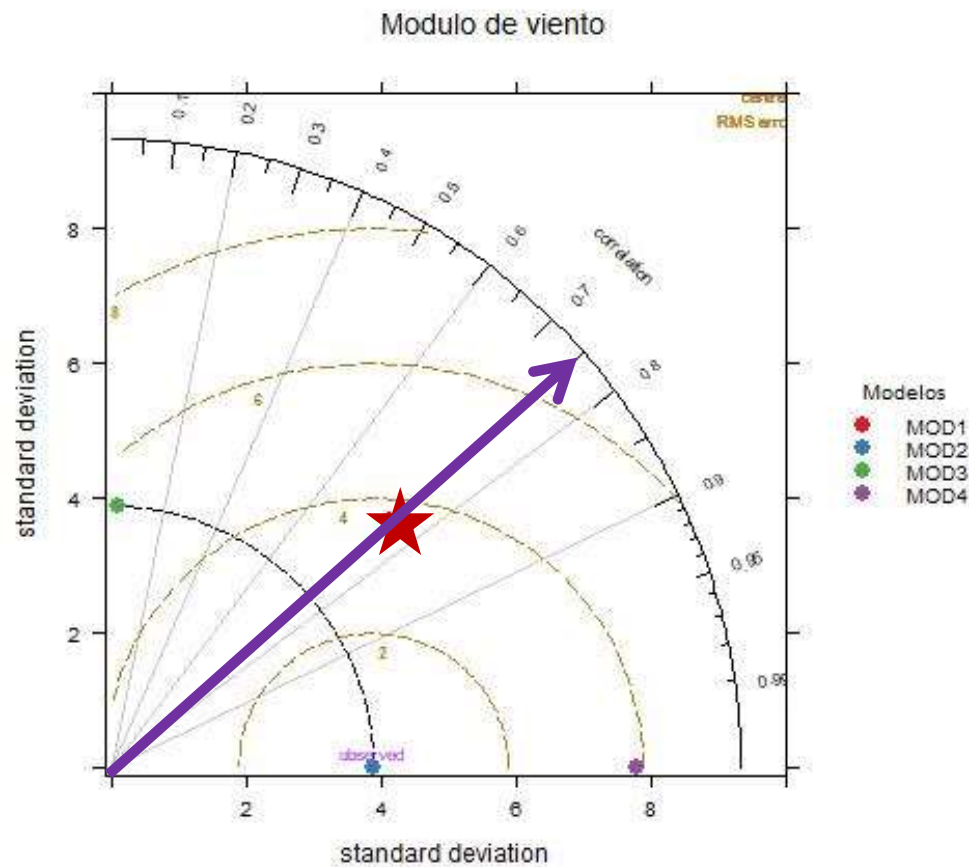
Taylor



```
> #Desviación Estandar  
> sd(OBS1)  
[1] 3.887556
```

```
> sd(MOD1)  
[1] 5.521965
```

Taylor

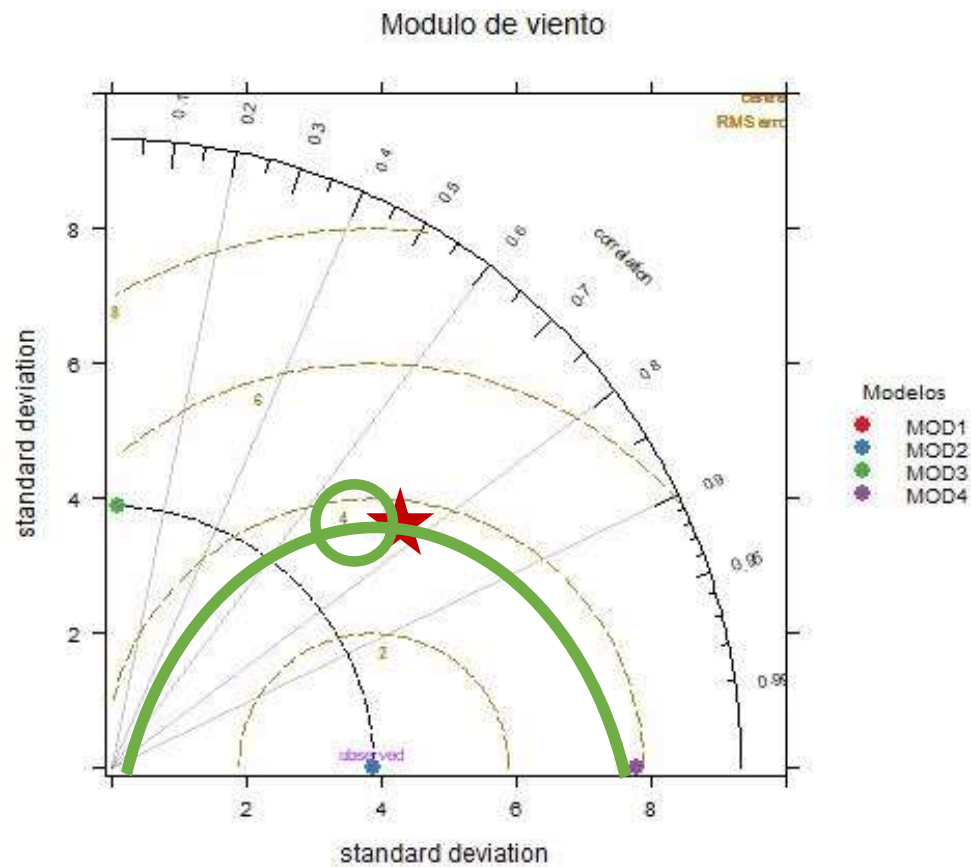


```
> #Desviación Estandar  
> sd(OBS1)  
[1] 3.887556
```

```
> sd(MOD1)  
[1] 5.521965
```

```
> #Correlación  
> cor(OBS1,MOD1)  
[1] 0.7483729
```

Taylor

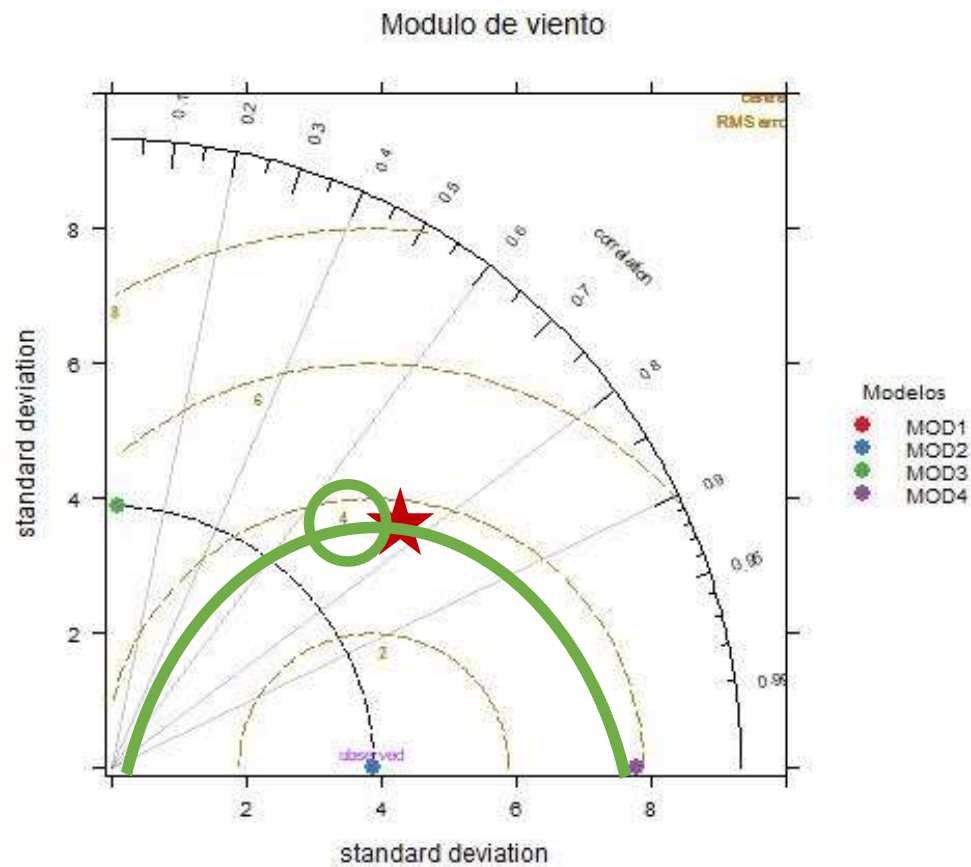


```
> #Desviación Estandar  
> sd(OBS1)  
[1] 3.887556
```

```
> sd(MOD1)  
[1] 5.521965
```

```
> #Correlación  
> cor(OBS1,MOD1)  
[1] 0.7483729
```

```
> #RMSE  
> rmse(OBS1,MOD1)  
[1] 7.4982
```

```
> #Desviación Estandar
> sd(OBS1)
[1] 3.887556
```

```
> sd(MOD1)
[1] 5.521965
```

```
> #Correlación
> cor(OBS1,MOD1)
[1] 0.7483729
```

```
> #RMSE
> rmse(OBS1,MOD1)
[1] 7.4982
```

```
> obs_mean<-mean(OBS1)
> mod_mean<-mean(MOD1)
> rmse(OBS1-obs_mean,MOD1-mod_mean)
[1] 3.670151
```

Taylor



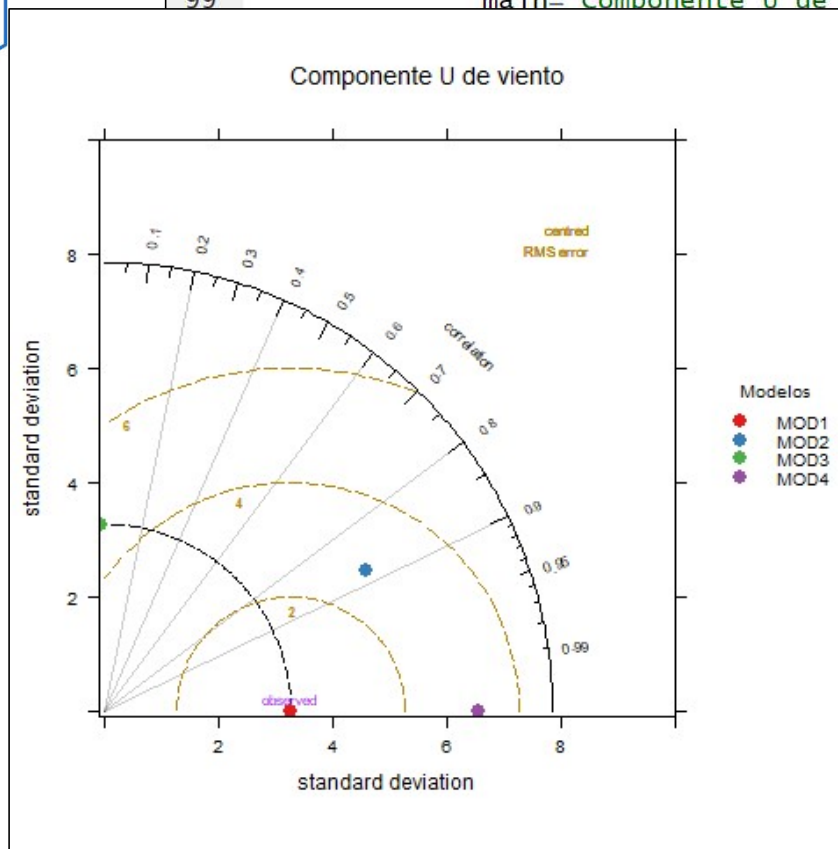
```
72
73 #Taylor U y V
74 #~~~~~
75 load("data_U.RData")
76 load("data_V.RData")
77
78 #Clase
79 class(data_U)
80 class(data_V)
81
82 #Nombres
83 names(data_U)
84 names(data_V)
85
86 #Taylor U
87 TaylorDiagram(data_U, obs = "obs_value",
88               mod = "mod_value", group="mod_name",
89               main="Componente U de viento",
90               key.title="Modelos",
91               xlim=c(-0.1,10),
92               ylim=c(-0.1,10))
93
```

```
> #Clase
> class(data_U)
[1] "data.frame"
> class(data_V)
[1] "data.frame"
> #Nombres
> names(data_U)
[1] "obs_name" "obs_value" "mod_name" "mod_value"
> names(data_V)
[1] "obs_name" "obs_value" "mod_name" "mod_value"
```

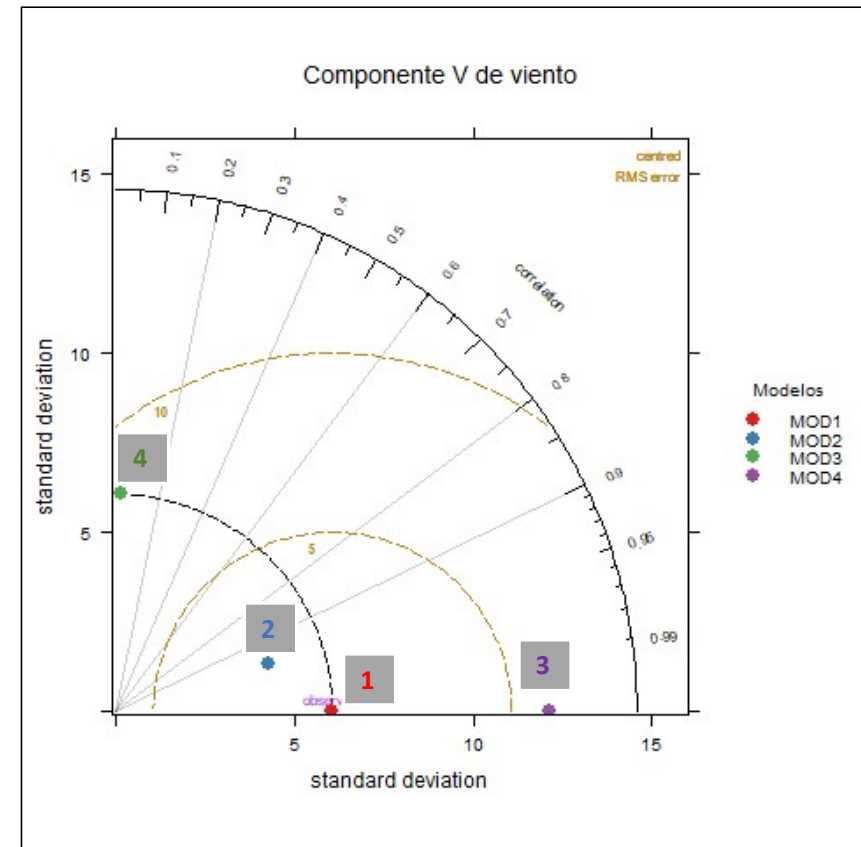
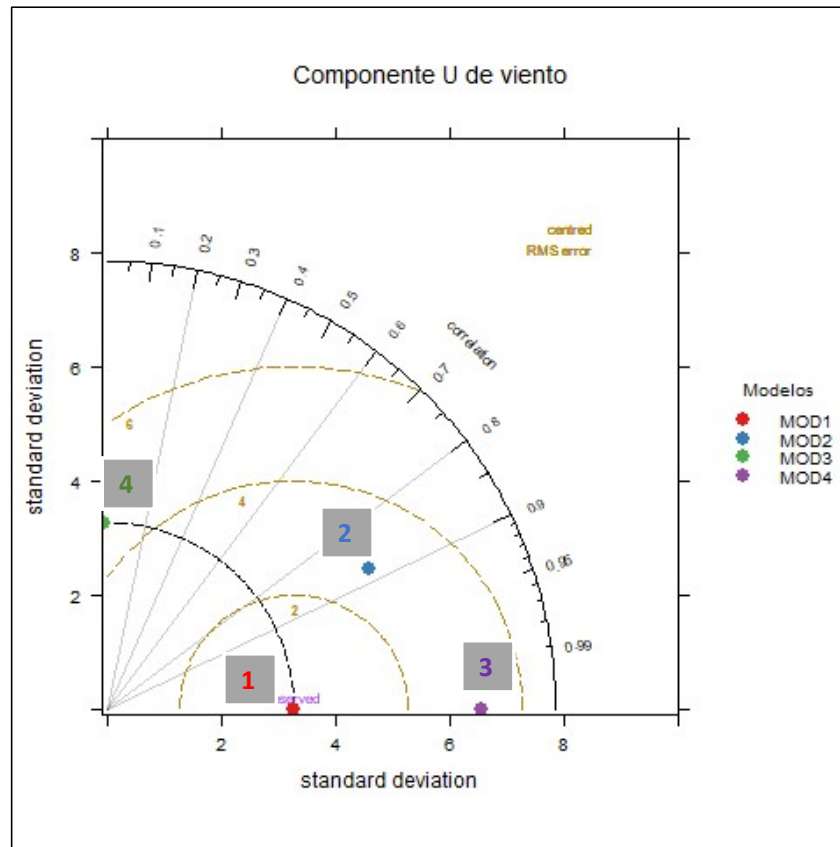

Taylor



```
95 #png
96 png("Taylor_U.png")
97 TaylorDiagram(data_U, obs = "obs_value",
98               mod = "mod_value", group="mod_name",
99               main="Componente U de viento",
```



Taylor



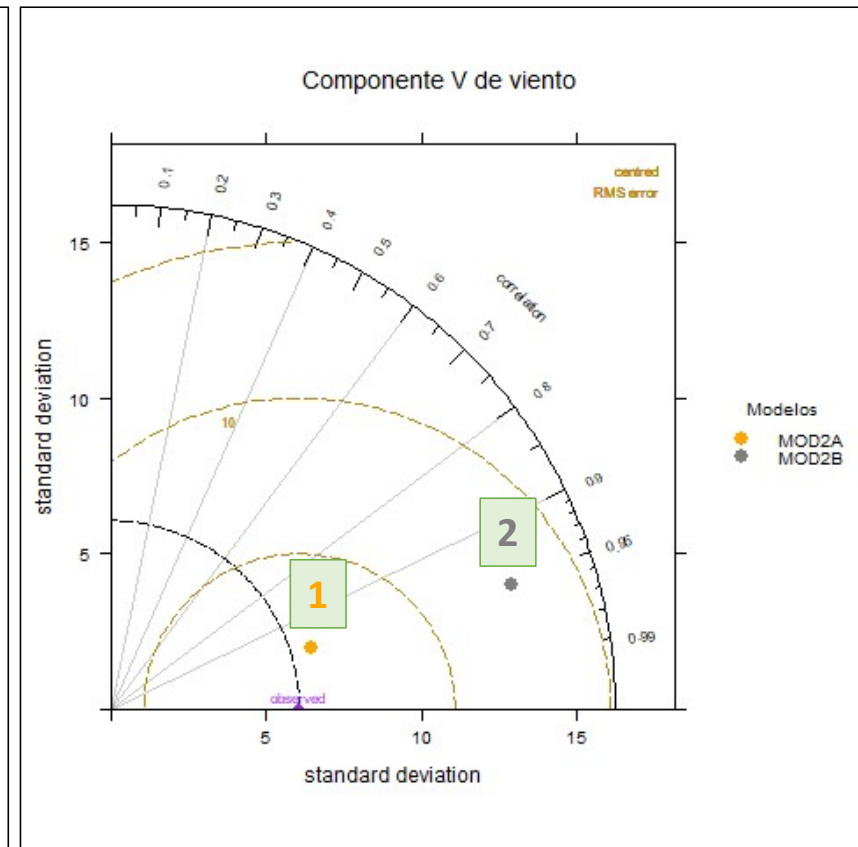
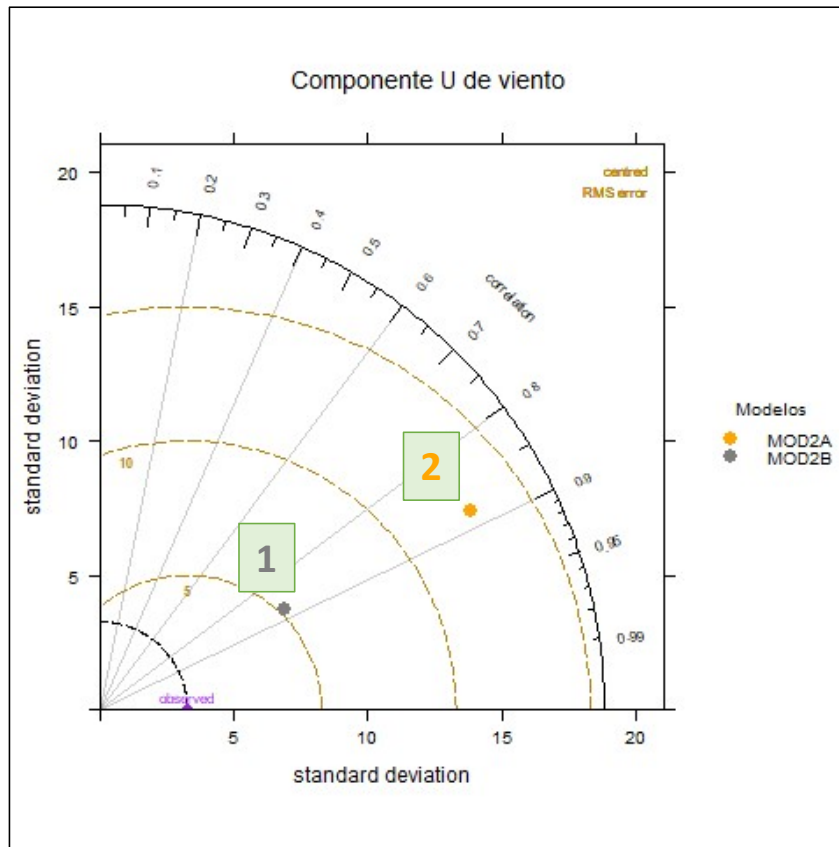
Taylor



```
125 #Diagramas de Taylor U y V contradictorios
126 #~~~~~
127
128 load("data_AB_U.RData")
129 load("data_AB_V.RData")
130
131 #Class
132 class(data_AB_U)
133 class(data_AB_V)
134
135 #Names
136 names(data_AB_U)
137 names(data_AB_V)
138
139
140 #Taylor U
141 TaylorDiagram(data_AB_U, obs = "obs_value",
142               mod = "mod_value", group="mod_name",
143               main="Componente U de viento",
144               key.title="Modelos",
145               cols=c("orange", "grey50"))
146
```

```
> #Class
> class(data_AB_U)
[1] "data.frame"
> class(data_AB_V)
[1] "data.frame"
> #Names
> names(data_AB_U)
[1] "obs_name" "obs_value" "mod_name" "mod_value"
> names(data_AB_V)
[1] "obs_name" "obs_value" "mod_name" "mod_value"
```

Taylor



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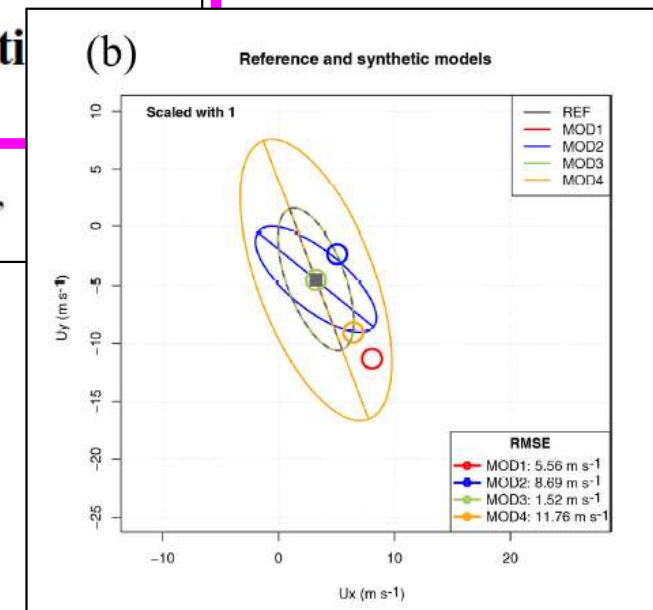
Sailor



El diagrama de Sailor – Un nuevo diagrama de verificación de vectores bidimensionales para múltiples modelos

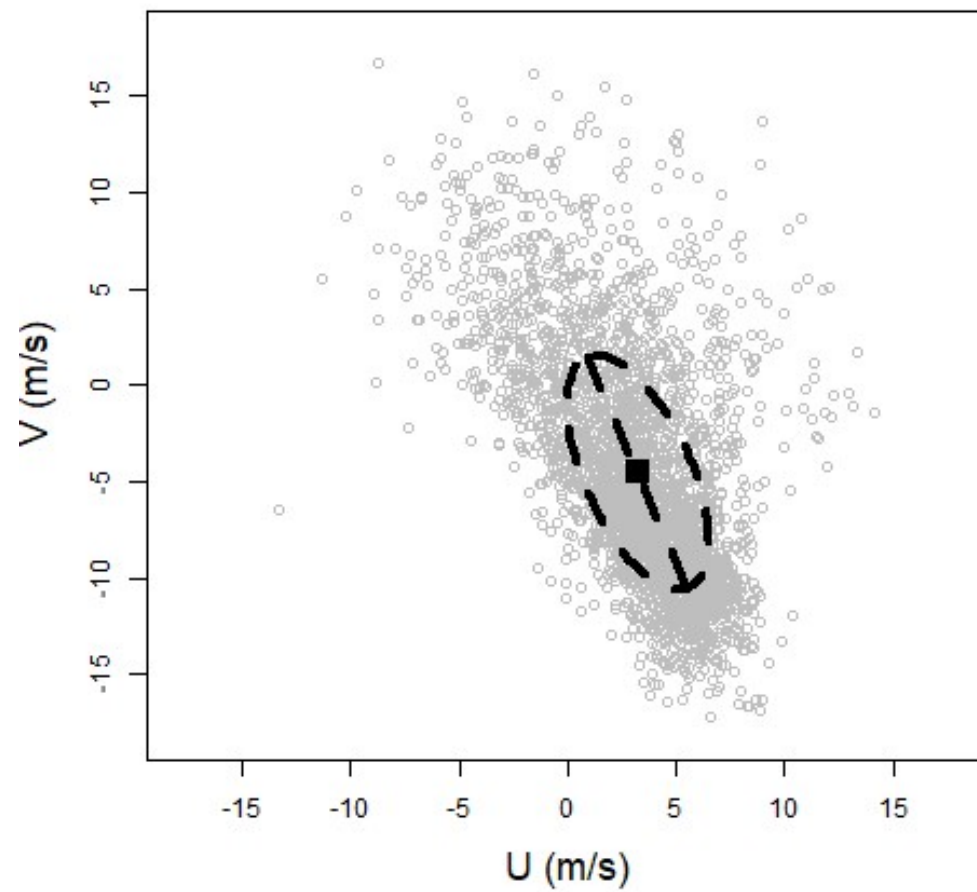
The Sailor diagram – A new diagram for the verification of two-dimensional vector data from multiple models

Jon Sáenz^{1,2}, Sheila Carreno-Madinabeitia^{3,4}, Ganix Esnaola^{5,2}, Santos J. González-Rojí^{6,7}, Gabriel Ibarra-Berastegi^{6,7}, and Alain Ulazia⁷



Sailor

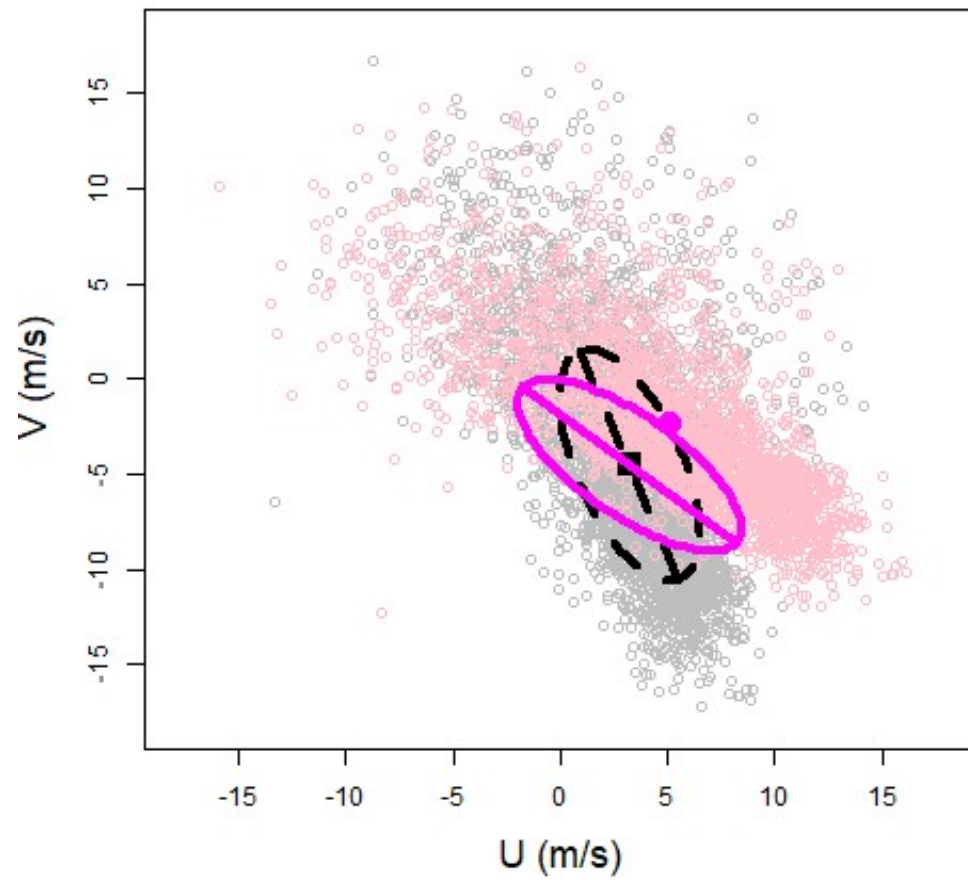
Synthetic



EOF o
Loading Factors

Sailor

Synthetic

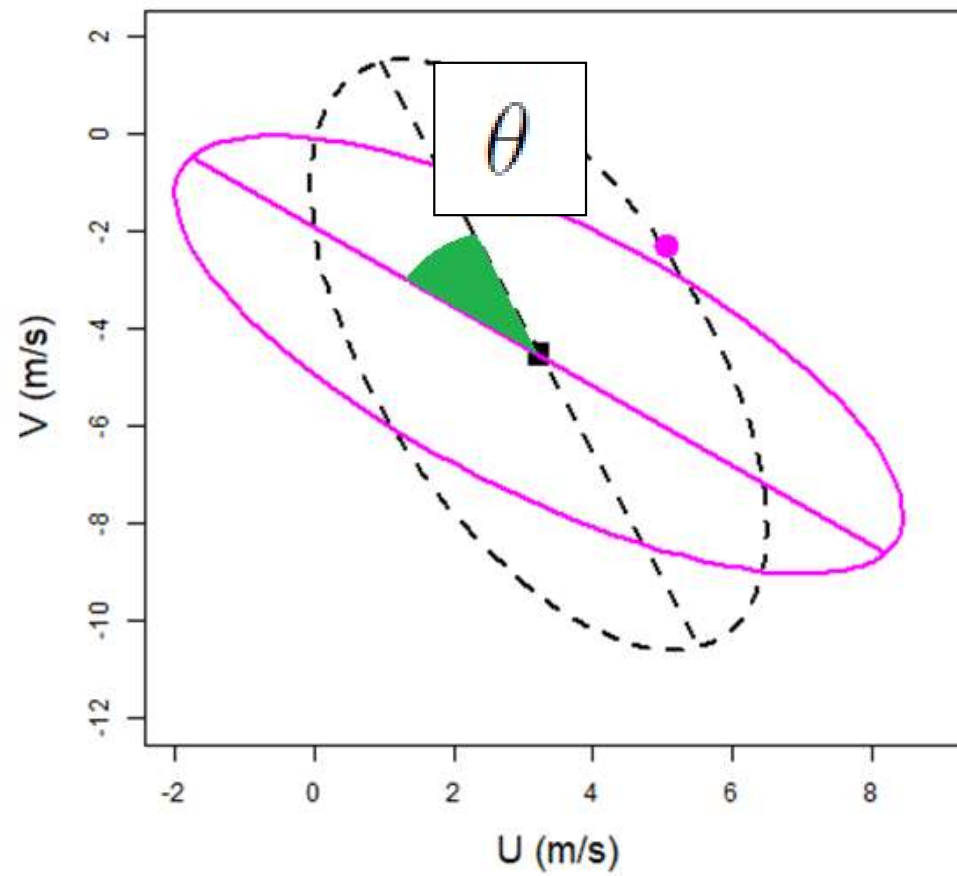


$$EOF = R \text{ EOF}$$

Observación
Modelo

Sailor

Synthetic



Sailor



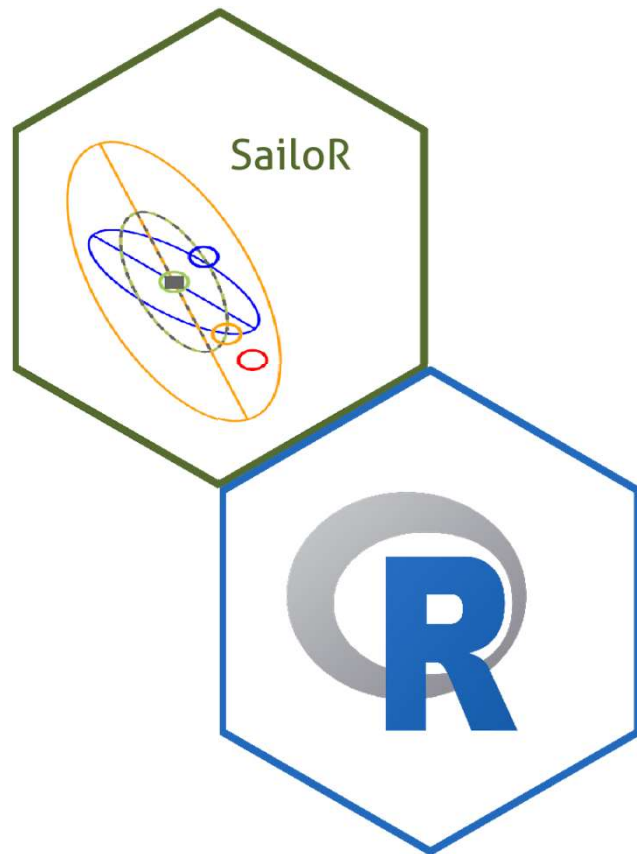
$$\Delta^2 = \frac{1}{N}B^2 + \frac{1}{N}C + \frac{1}{N}D$$

Sesgo

Null

SD

Sailor



- Paquete R
- Distribución libre
- Gráficos
- Índices de diagnostico
- Opción personalizar
 - Datos espaciales
 - Sistema de predicción por conjuntos
- Incluye ejemplos

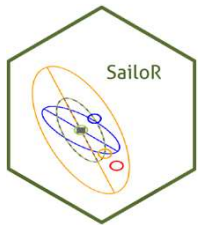
Taylor



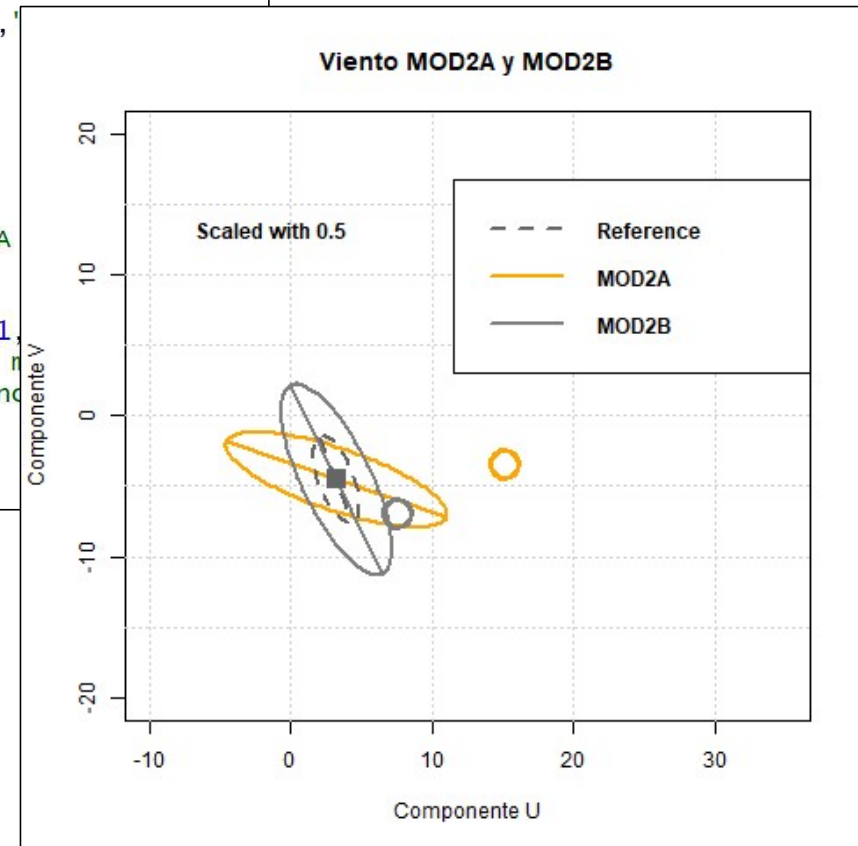
```
173
174 #SailoR
175 #~~~~~
176
177 #Diagrama U y V contradictorios
178 #Modelos en Synthetic$mod
179 load("Synthetic_AB.RData")
180 names(Synthetic_AB)
181
182 #Clase
183 class(Synthetic_AB$ref)
184 class(Synthetic_AB$mod)
185
186 #Nombres
187 names(Synthetic$ref)
188 names(Synthetic$mod)
189
190 head(Synthetic$ref)
191 head(Synthetic$ref)
192
193 #Dimensiones
194 dim(Synthetic_AB$ref)
195 dim(Synthetic_AB$mod)
196
```

```
> load("Synthetic_AB.RData")
> names(Synthetic_AB)
[1] "ref" "mod"
> #Clase
> class(Synthetic_AB$ref)
[1] "data.frame"
> class(Synthetic_AB$mod)
[1] "data.frame"
> #Nombres
> names(Synthetic$ref)
[1] "mod" "U" "V"
> names(Synthetic$mod)
[1] "mod" "U" "V"
> head(Synthetic$ref)
  mod      U      V
1 REF 4.062642 -3.245021
2 REF 3.875312 -8.416519
3 REF 5.482183 -9.673779
4 REF 7.148167 -11.815594
5 REF 4.764503 -11.496723
6 REF 4.966819 -12.368854
> #Dimensiones
> dim(Synthetic_AB$ref)
[1] 2920 3
> dim(Synthetic_AB$mod)
[1] 5840 3
```

Taylor



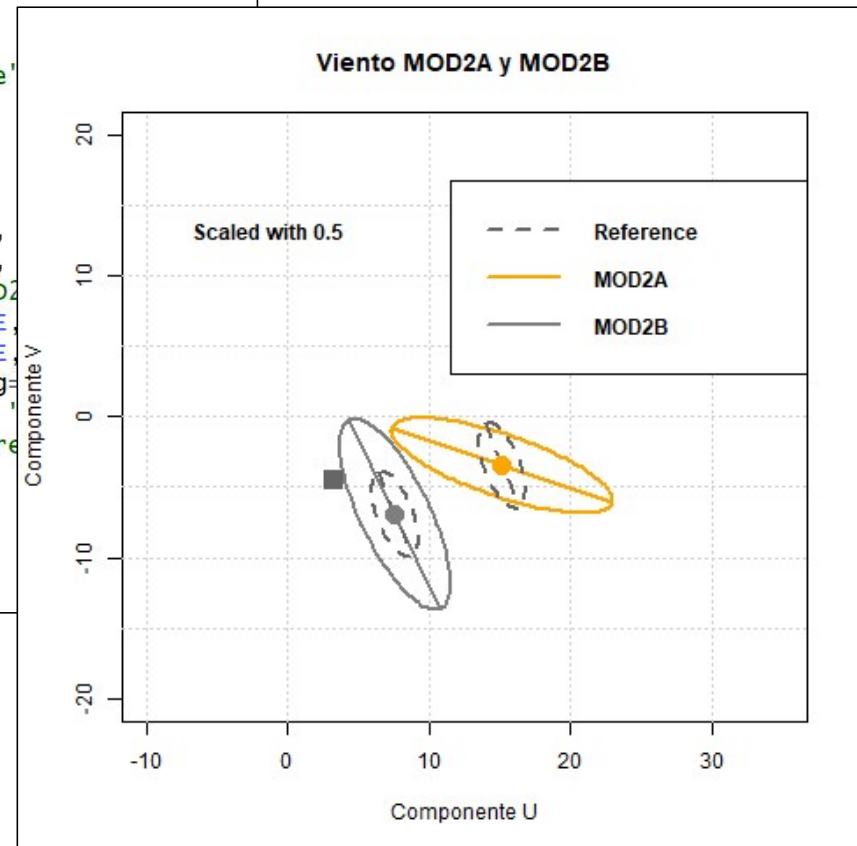
```
198 p <- sailoR.Plot(Synthetic_AB$ref,  
199                 Synthetic_AB$mod,  
200                 colourList=c("orange",  
201                               sfactor=0.5,  
202                               docenter=TRUE,  
203                               xlim=c(-10,35),  
204                               ylim=c(-15,15),  
205                               xlab="Componente U",  
206                               ylab="Componente V",  
207                               plotmain="Viento MOD2A  
208                               plotRMSElegend=FALSE,  
209                               plotscalelegend=TRUE,  
210                               RMSE_legend_Rounding=1,  
211                               RMSE_legend_units = "R",  
212                               referenceName="Referenc  
213 png("sailor_MOD2AB.png")  
214   p  
215 dev.off()
```



Taylor



```
218 #Sin centrar
219 p <- Sailor.Plot(Synthetic_AB$ref,
220                 Synthetic_AB$mod,
221                 colourList=c("orange",
222                               "black"),
223                 cfactor=0.5,
224                 docenter=FALSE,
225                 xlim=c(-10,35),
226                 ylim=c(-15,15),
227                 xlab="Componente U",
228                 ylab="Componente V",
229                 plotmain="Viento MOD2",
230                 plotRMSElegend=FALSE,
231                 plotscalelegend=TRUE,
232                 RMSE_legend_Rounding=
233                 RMSE_legend_units = "
234                 referenceName="Referen
235 png("sailor_MOD2AB_sinCentrar.png")
236 p
237 dev.off()
238
```

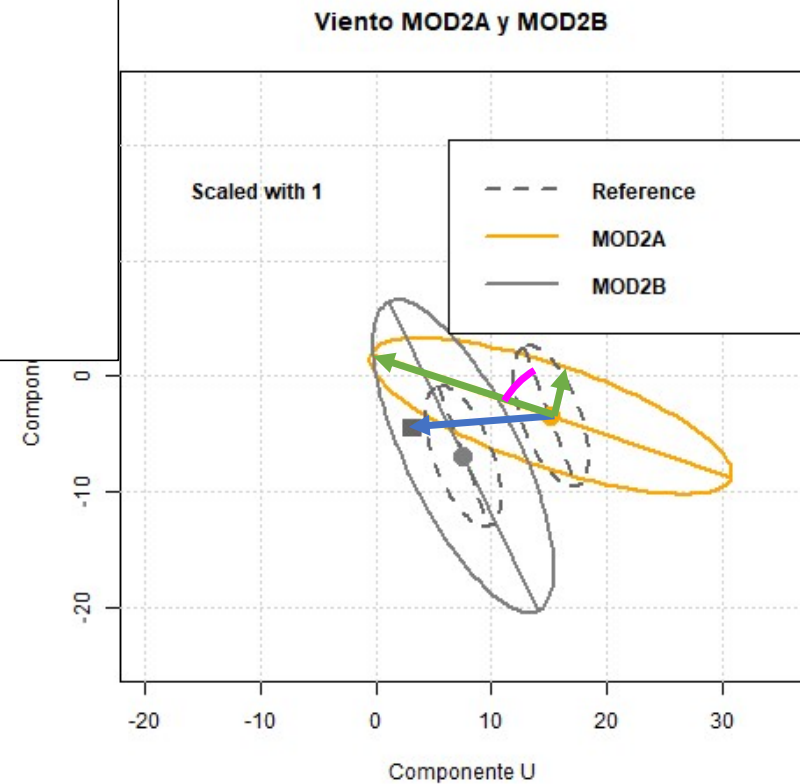


Taylor



```
240 #Indices
241 Indices <- sailoR.Indices(Synthetic_AB$ref,
242                           synthetic_AB$mod)
243
244 names(Indices$MOD2A)
245 sqrt(sum(Indices$MOD2A$meanV^2))
246 Indices$MOD2A$sdvx
247 Indices$MOD2A$sdvy
248 Indices$MOD2A$thetavu
249
250 sqrt(sum(Indices$MOD2B$meanV^2))
251 Indices$MOD2B$sdvx
252 Indices$MOD2B$sdvy
253 Indices$MOD2B$thetavu
254
```

```
> sqrt(sum(Indices$MOD2A$meanV^2))
[1] 15.56117
> Indices$MOD2A$sdvx
[1] 15.66284
> Indices$MOD2A$sdvy
[1] 6.758816
> Indices$MOD2A$thetavu
[1] 0.8802886
```



Taylor



```

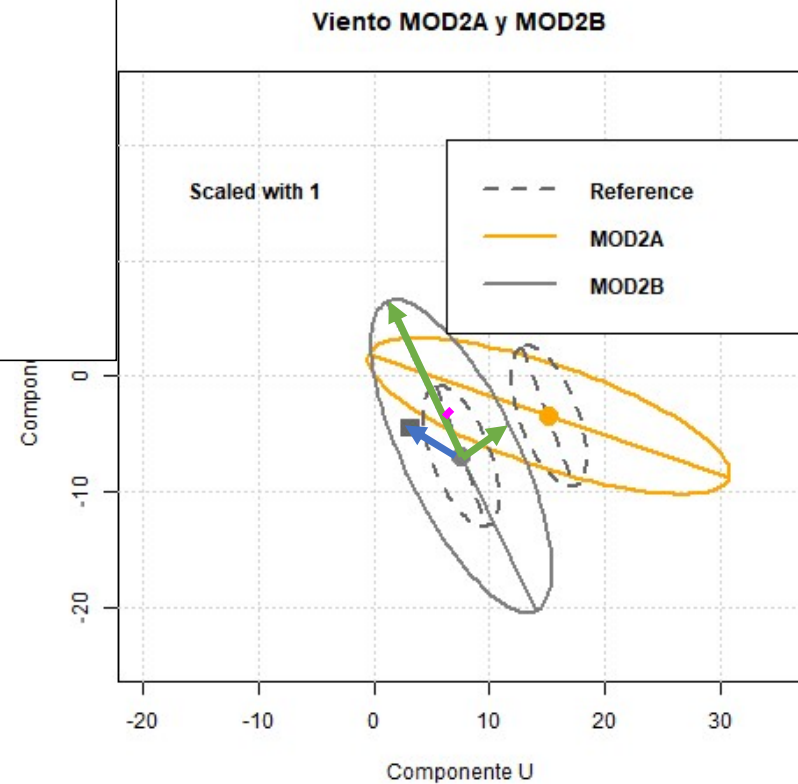
240 #Indices
241 Indices <- sailoR.Indices(Synthetic_AB$ref,
242                           synthetic_AB$mod)
243
244 names(Indices$MOD2A)
245 sqrt(sum(Indices$MOD2A$meanV^2))
246 Indices$MOD2A$sdvx
247 Indices$MOD2A$sdvy
248 Indices$MOD2A$thetavu
249
250 sqrt(sum(Indices$MOD2B$meanV^2))
251 Indices$MOD2B$sdvx
252 Indices$MOD2B$sdvy
253 Indices$MOD2B$thetavu
254

```

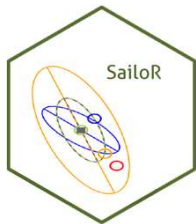
```

> sqrt(sum(Indices$MOD2A$meanV^2))
[1] 15.56117
> Indices$MOD2A$sdvx
[1] 15.66284
> Indices$MOD2A$sdvy
[1] 6.758816
> Indices$MOD2A$thetavu
[1] 0.8802886
> sqrt(sum(Indices$MOD2B$meanV^2))
[1] 10.26709
> Indices$MOD2B$sdvx
[1] 7.831422
> Indices$MOD2B$sdvy
[1] 13.51763
> Indices$MOD2B$thetavu
[1] 0.08940617

```



Taylor



```

254
255 #Tabla Indices
256 Tabla<-SailoR.Table(Indices,round_digits = 1)
257 Tabla
258
259 #Tabla Latex:
260 #library(xtable)
261 #oInfo<-xtable(Tabla)
262 #print(oInfo,type="latex",file="table.tex")
263

```

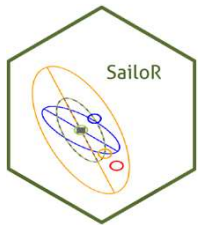
```

> #Tabla Indices
> Tabla<-SailoR.Table(Indices,round_digits = 1)
> Tabla
  modelName sdUx sdUy sdVx sdVy sigmax sigmay thetau thetav thetavu R2vec
1      Ref   3.3   6.1   NA   NA    6.4    2.5    1.9    NA     NA      2
2    MOD2A   NA   NA  15.7   6.8   16.5    4.4    NA    2.8    0.9      2
3    MOD2B   NA   NA   7.8  13.5   14.8    4.9    NA    2.0    0.1      2
  biasMag RMSE Eccentricity congruence EOF1
1      0  0.0              0.9          1.0
2     12 13.2              1.0          0.6
3      5 12.9              0.9          1.0
>

```

	modelName	sdVx	sdVy	Sigmax	Sigmay	thetau	thetav	R2vec	biasMag	RMSE
1	Ref			6.40	2.50	1.90		2.00	0.00	0.00
2	MOD2A	15.70	6.80	16.50	4.40		2.80	2.00	12.00	13.20
3	MOD2B	7.80	13.50	14.80	4.90		2.00	2.00	5.00	12.90

Taylor



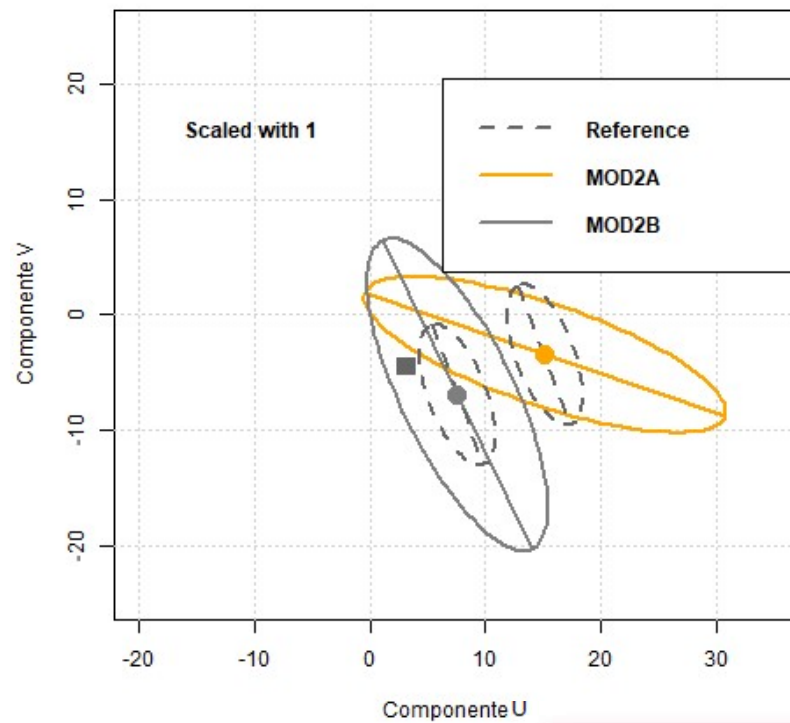
```
246  
247 #Tabla Latex:  
248 #library(xtable)  
249 #oInfo<-xtable(Tabla)  
250 #print(oInfo,type="latex",file="table.tex")  
251
```

	modelName	sdVx	sdVy	Sigmax	Sigmay	thetau	thetav	R2vec	biasMag	RMSE
1	Ref			6.40	2.50	1.90		2.00	0.00	0.00
2	MOD2A	15.70	6.80	16.50	4.40		2.80	2.00	12.00	13.20
3	MOD2B	7.80	13.50	14.80	4.90		2.00	2.00	5.00	12.90

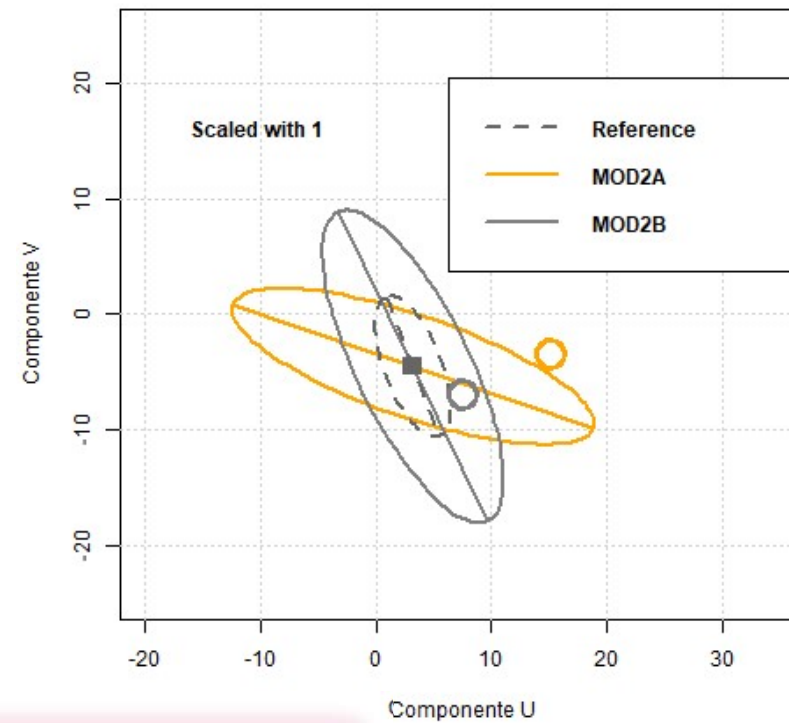
Taylor



Viento MOD2A y MOD2B



Viento MOD2A y MOD2B



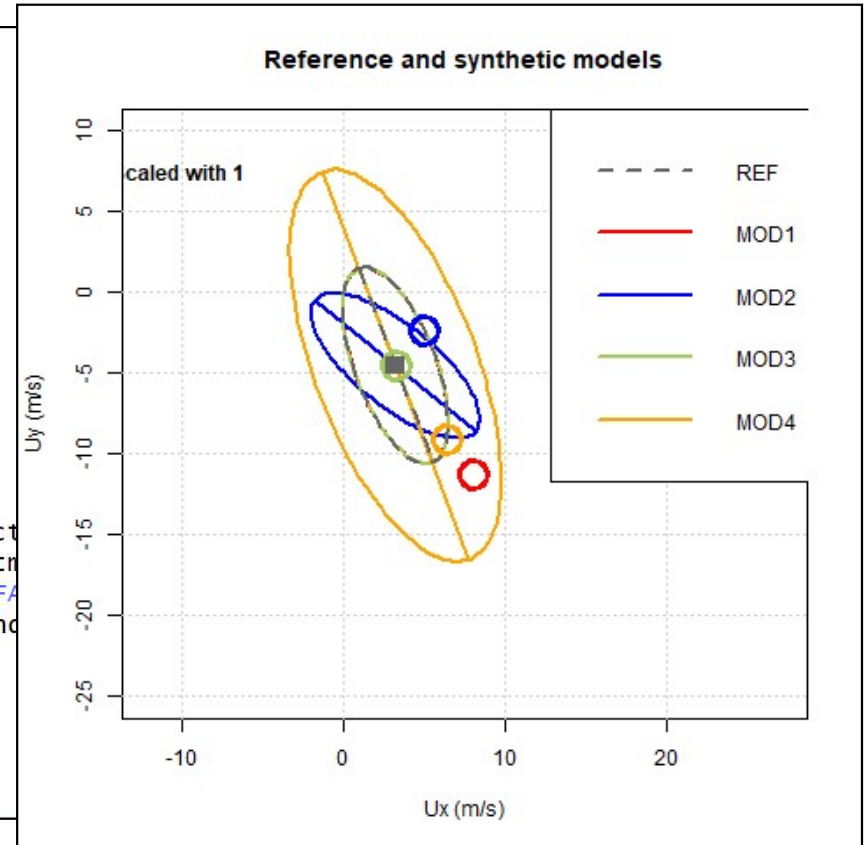
MOD2B es mejor MOD2A

Taylor



```
265 #Mas ejemplos
266 #~~~~~
267 data(Synthetic)
268 names(Synthetic)
269
270 #Parametros
271 ref<-Synthetic$ref
272 mod<-Synthetic$mod
273 Uxlim=c(0,15)
274 Uylim=c(-25,10)
275 Uxlab<-"Ux (m/s)"
276 Uylab<-"Uy (m/s)"
277 plotmain<-"Reference and synthetic models"
278 sfactor<-1
279
280
281 p<-SailoR.Plot(ref,mod,ColourList=NULL, sfact
282               Uxlim, Uylim, Uxlab, Uylab, plotm
283               Ensembles=TRUE plotRMSElegend=FA
284               SE_legend
285               "s")
```

MOD1: sego añadido a la ref.
MOD2: ref. rotada
MOD3: valores de la ref. permutados
MOD4: ref. escalada



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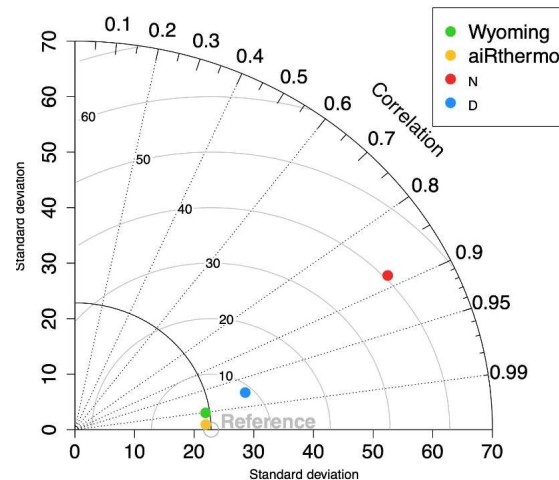
Aplicaciones : Taylor



Changes in the simulation of atmospheric instability over the Iberian Peninsula due to the use of 3DVAR data assimilation

Santos J. González-Rojí^{1,2}, Sheila Carreno-Madinabeitia^{3,4}, Jon Sáenz^{5,6}, and Gabriel Ibarra-Berastegi^{7,6}

CAPE- Santander (08023)



Aplicaciones: Taylor



S. J. González-Rojí et al.: Changes in the simulation of atmospheric instability over the IP

3479

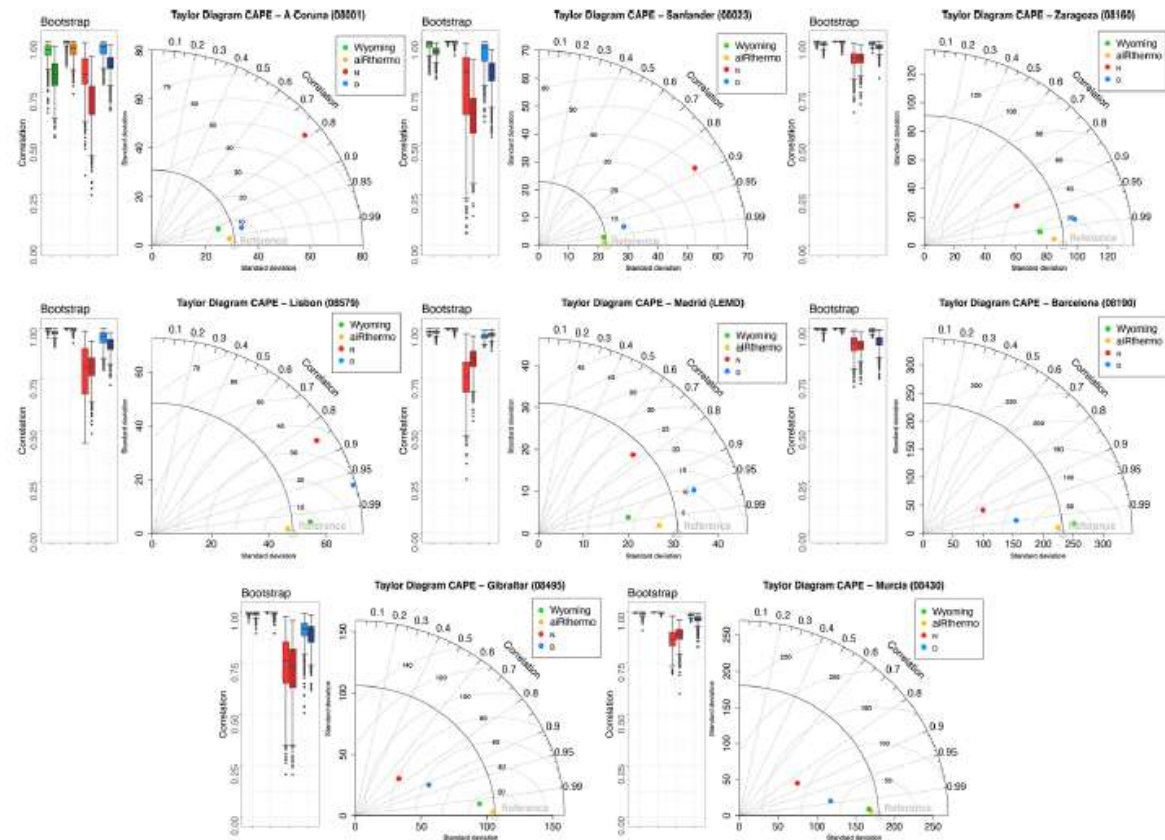


Figure 3. Same as Fig. 2 but for CAPE.

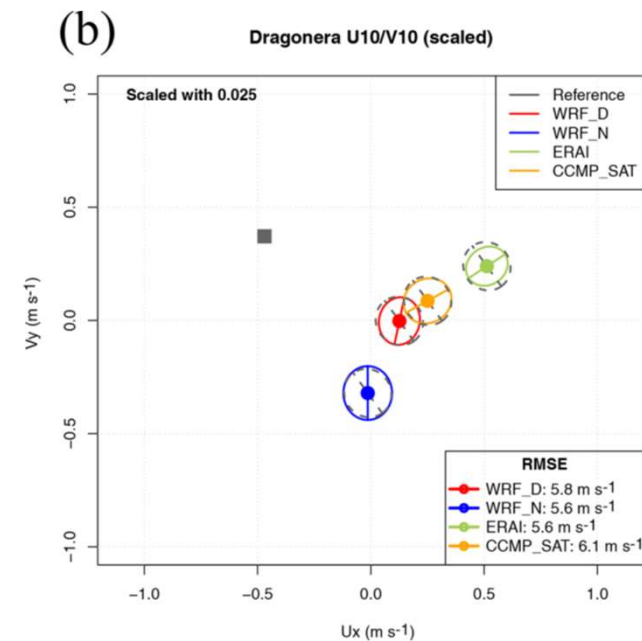
Aplicaciones : Sailor



The Sailor diagram – A new diagram for the verification of two-dimensional vector data from multiple models

Jon Sáenz^{1,2}, Sheila Carreno-Madinabeitia^{3,4}, Ganix Esnaola^{5,2}, Santos J. González-Rojí^{6,7}, Gabriel Ibarra-Berastegi^{8,2}, and Alain Ulazia⁹

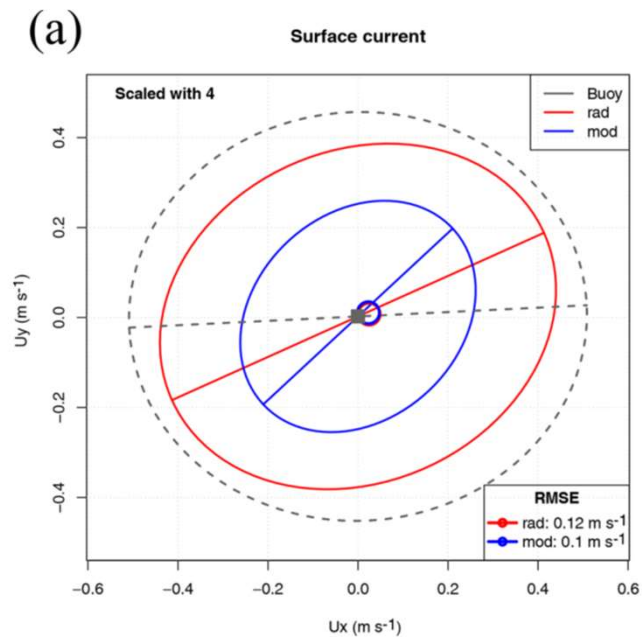
Viento sobre una
localización en el
Mediterráneo



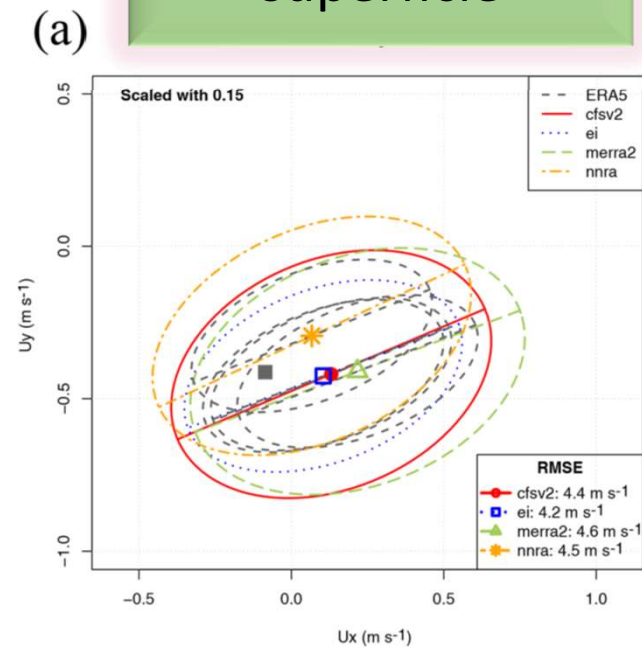
Aplicaciones : Sailor



Correinte en
superficie en el
golfo de Bizkaia

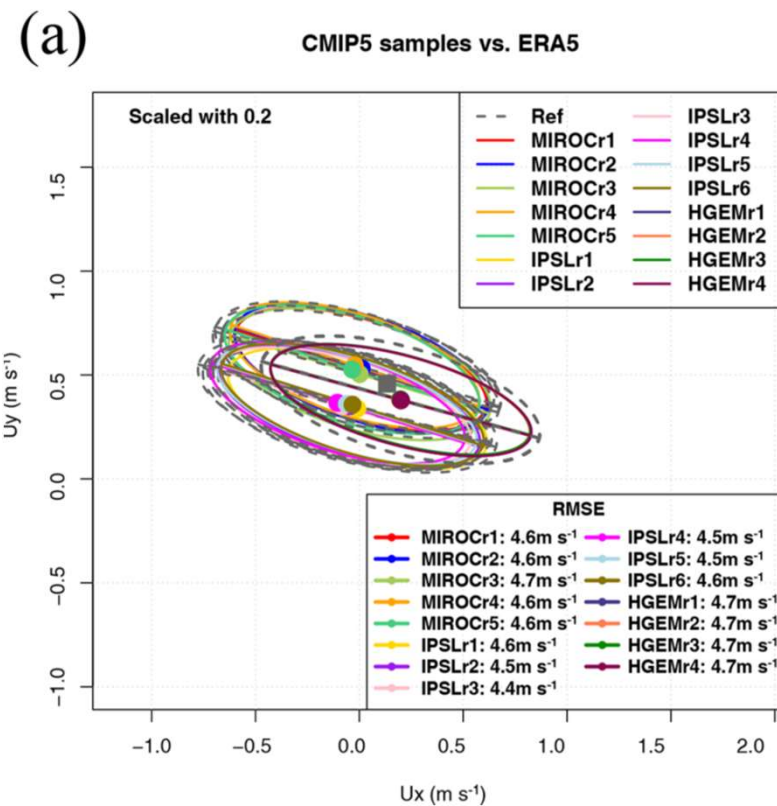
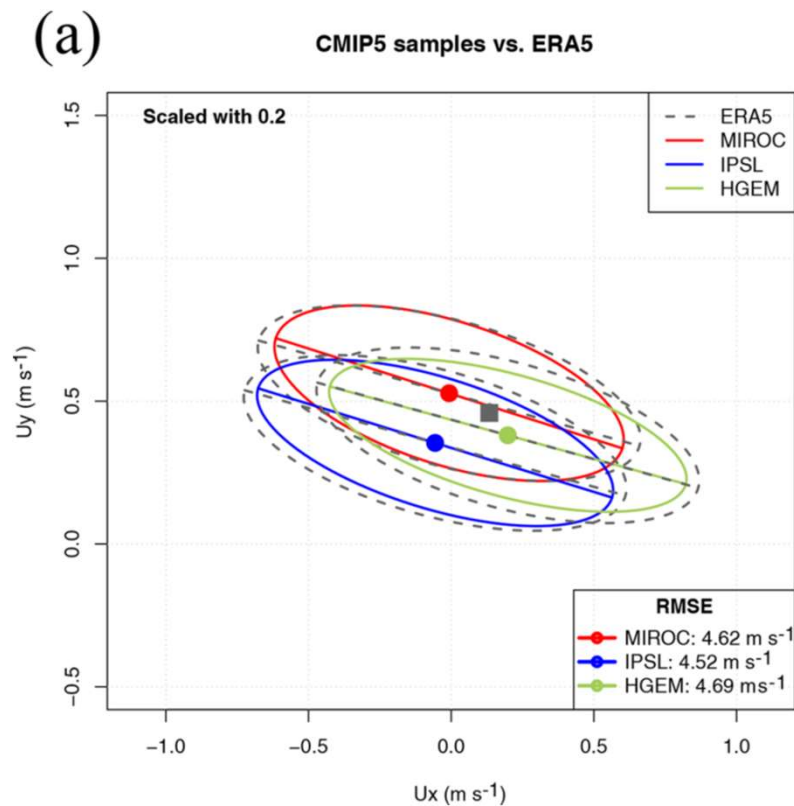


Distribución
especial de medias
estacionales de
viento en
superficie



Aplicaciones : Sailor

Modelos ensembles de la variable viento



Aplicaciones : Sailor



LANA :

ERA5 BIRANALISIAREN OLATU DATUEN ZEHAZTASUNA
ETA HONEN BILAKAERA ESPAZIALA ESPAINIAKO
KOSTALDEAN

Gradua: Energia Berriztagarrien Ingeniaritza

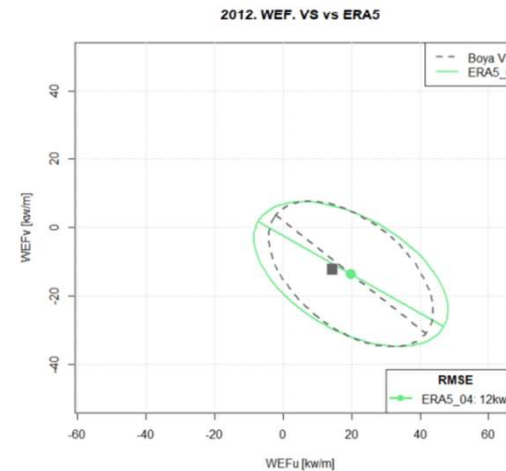
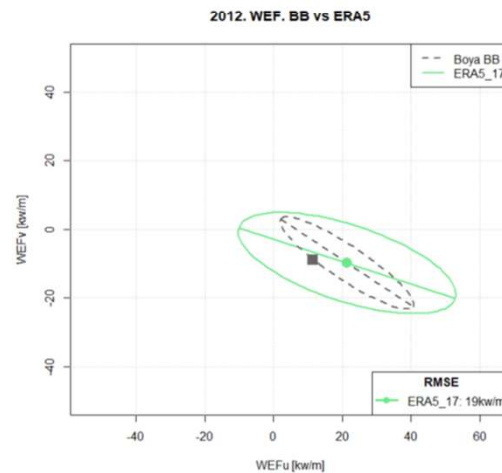
Ikasturtea: 2020 - 2021

Egilea: Mikel Garro Aguilar

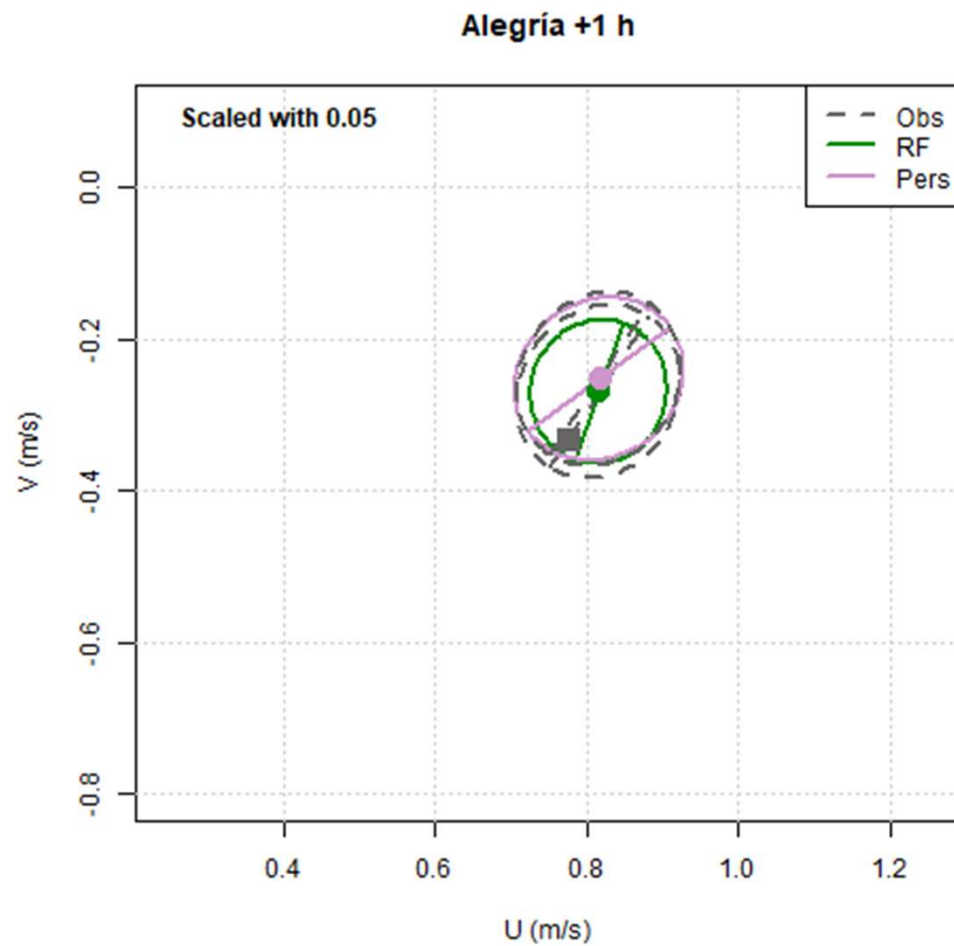
Zuzendaria: Gabriel Ibarra Berastegui

Zuzendarikidea: Alain Ulazia Manterola

WEF (Flujo de Energia de Olas) en diferentes boyas



2. Diagrama de Sailor



Predicción viento
+1h hasta +4hde
Estación de Alegria

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Conclusiones



Taylor

- Comparar modelos de variables unidimensionales
- Relaciona sd, cor, RMSE centrado
- Paquete de libre distribución de R: *openair* y *plotrix*

Sailor

- Comparar modelos de variables bidimensionales
- Se ha relacionado el RMSE con el sesgo, la varianza y la rotación de los EOFs
- Paquete de libre distribución de R: *SailoR*

Gracias

