Drone classification with trajectories :
identifying drones in the Russian-Ukrainian war

Romain Jaffuel, William Smith, Florian Grolleau

20/12/2024

UAVs as a newborn tool in modern warfare

INTERNATIONAL • WAR IN UKRAINE

Musk says Starlink stopped a Ukraine drone attack on Russian fleet

The tech billionaire Elon Musk says that his company SpaceX was asked to activate its satellite internet service Starlink in the Black Sea, to enable a Ukrainian attack on Russia's fleet.

Le Monde with AFP

Published on September 8, 2023, at 3:40 pm (Paris), updated on September 8, 2023, at 3:48 pm • 1 min read

Ukrainian naval drone with a Starlink terminal

Starlink potential role over the conflict

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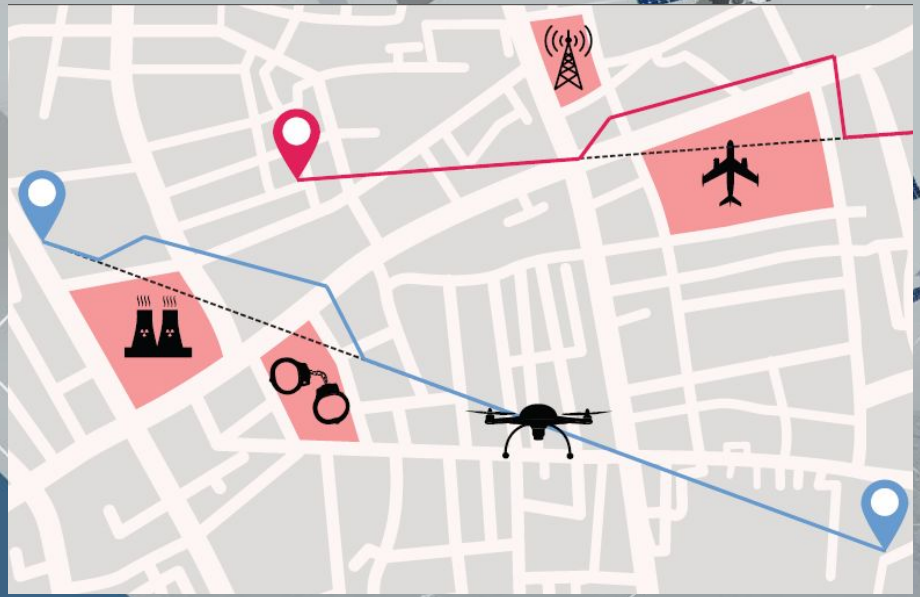
Starlink potential role over the conflict

What implies geofencing ?



Number of Suicide-Drones shot down (daily)

Methods: Collecting and process data

ORYX

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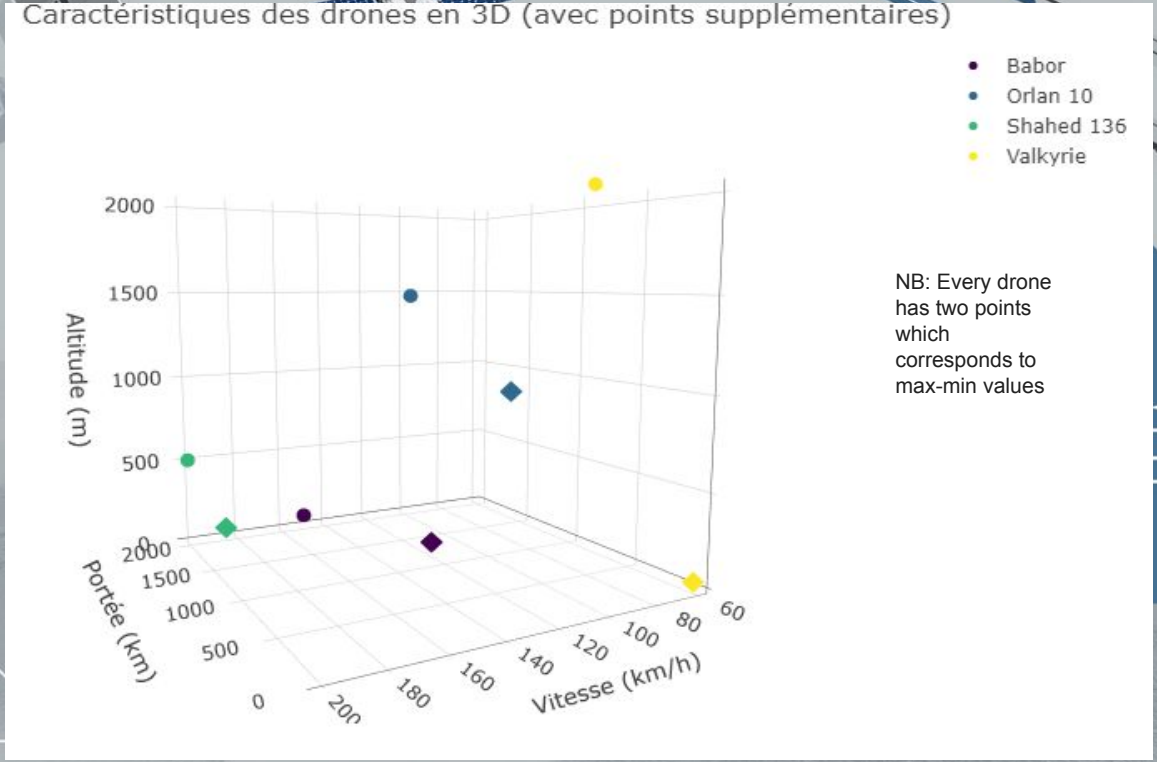
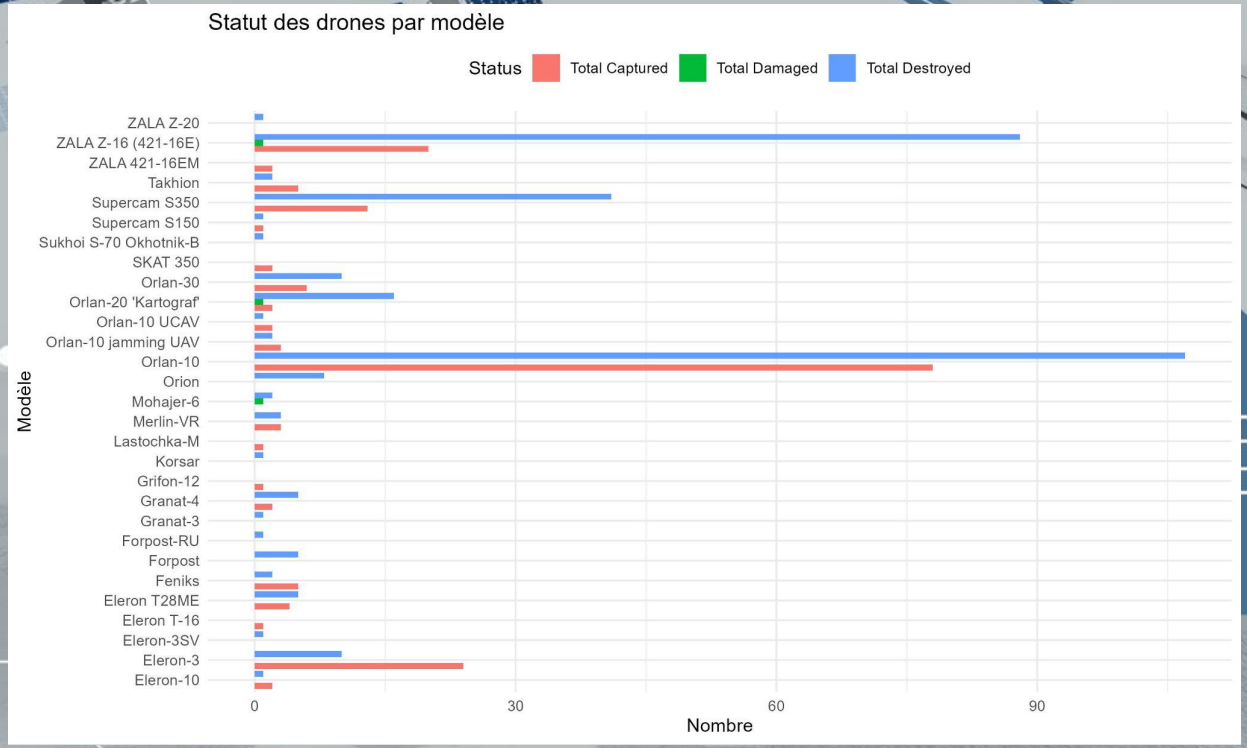
Methods: Collecting and process data



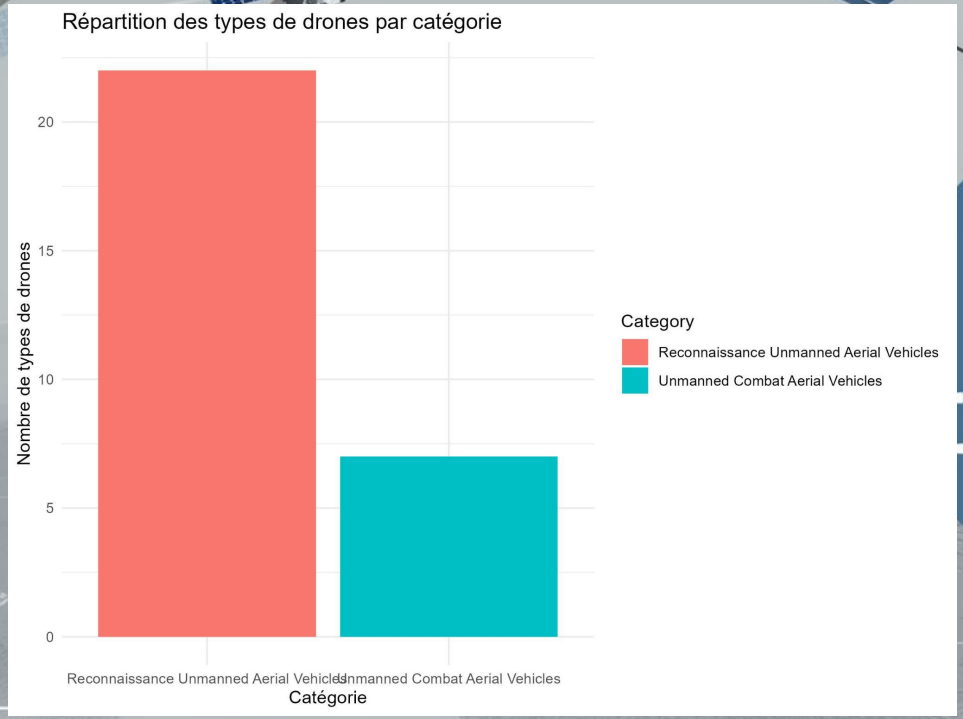
Methods: Collecting and process data

	Nom	Origine	Type	Altitudemax	Vitessemax	Range.km	Altitudemin	Cruisespeed.km	usualrange.km
1	Shahed 136	Russe	Suicide	500	200	2000	50	185	1000
2	Orlan 10	Russe	Reconnaissance	1500	150	600	1000	110	110
3	Babor	Ukrainien	Suicide	400	180	900	150	130	300
4	Valkyrie	Ukrainien	Reconnaissance	2000	108	34	30	60	34

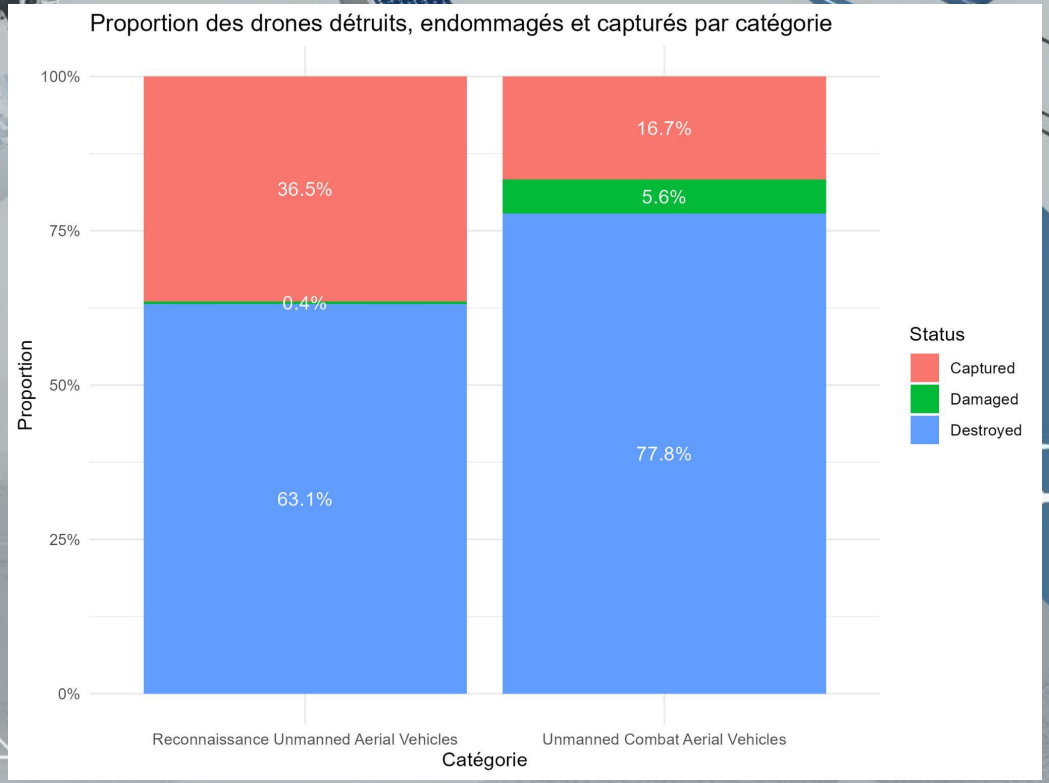
Number of Suicide-Drones shot down (daily)



Data Visualisation



Number of Suicide-Drones shot down (daily)



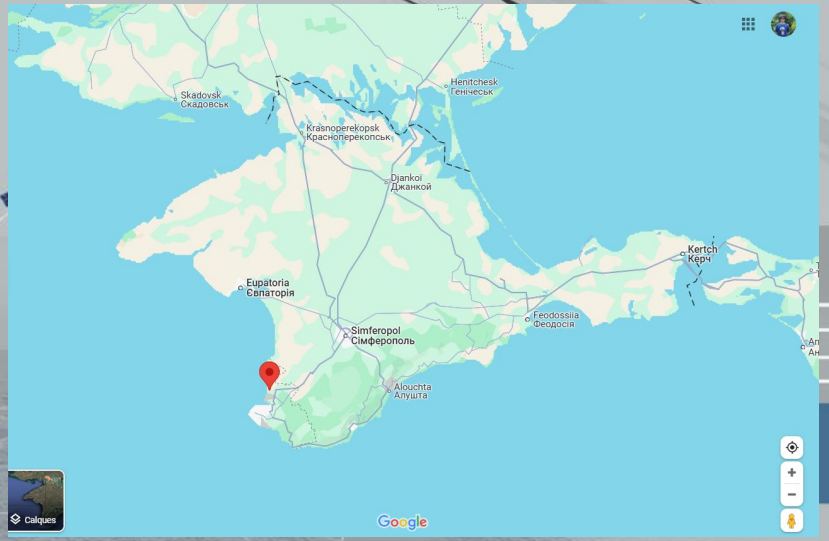
Framing of issue

How know if the drone is Russian or Ukrainian ?

Synopsis: The aim is to create an algorithm capable of detecting whether a drone is a “reconnaissance drone” or a “suicide drone” and if it is a Russian or Ukrainian. To achieve this, we will use Machine Learning

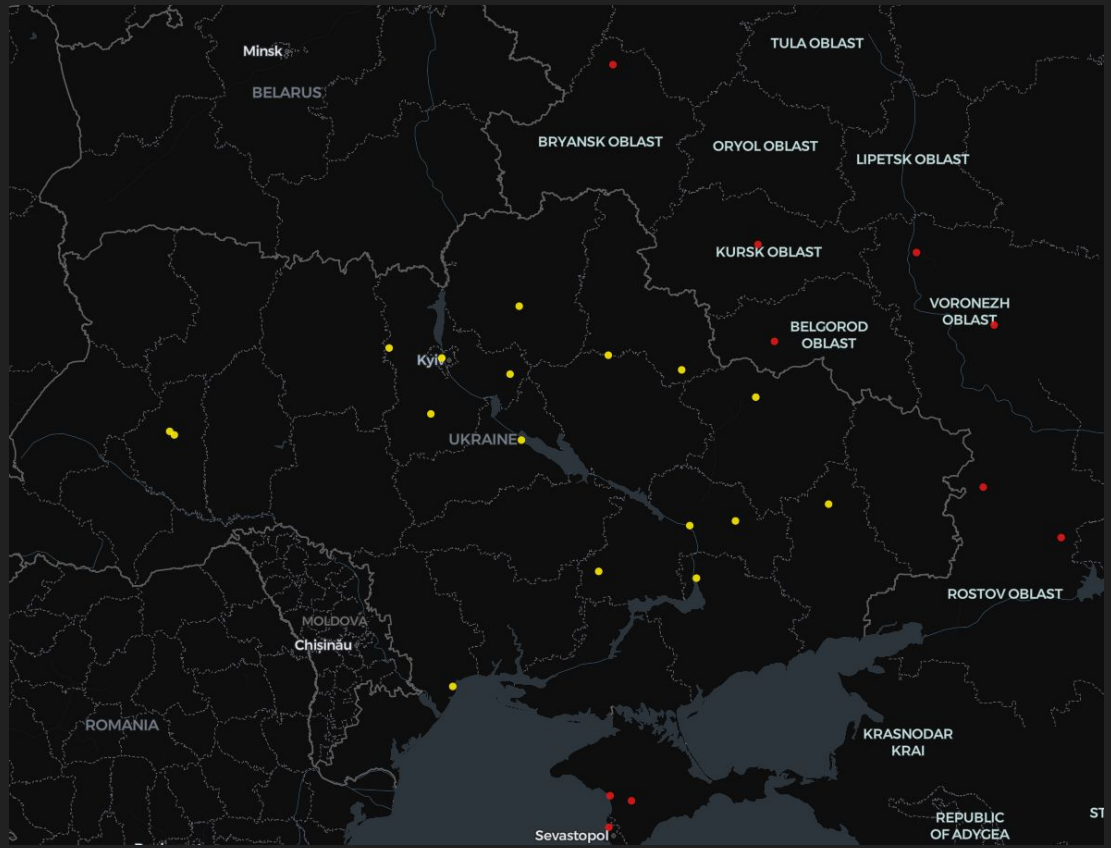
Type	Russian		Ukrainian	
Suicide	Shahed-136		Babor	
Recon	Orlan-10		Valkyrie	

Locate major Russian air bases

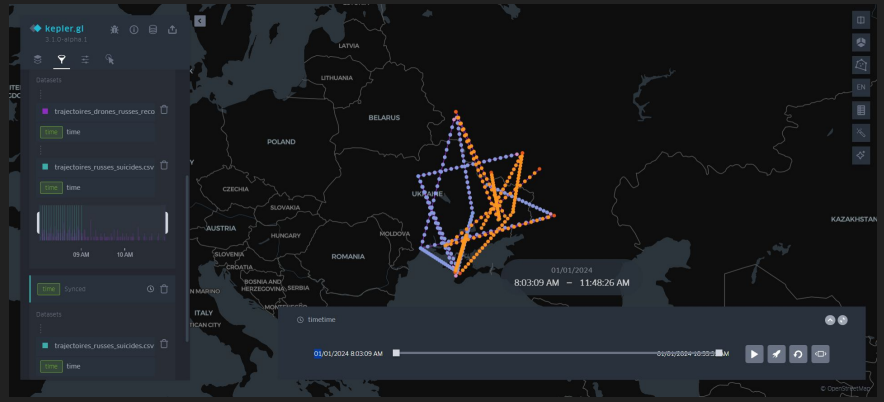


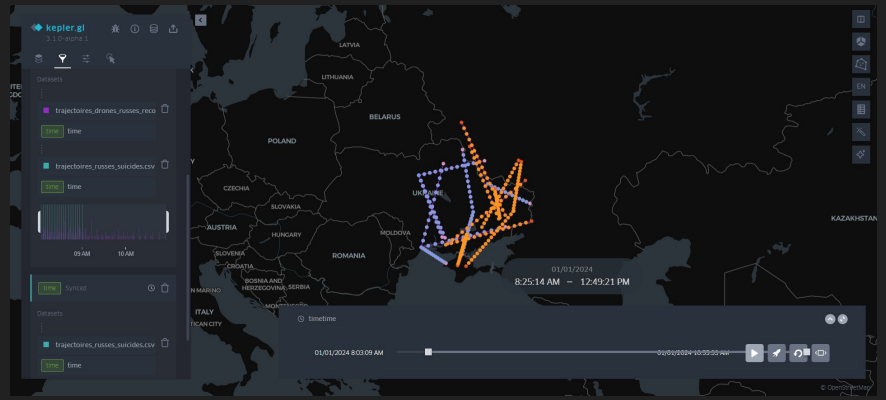
Satellite image ©2024 Maxar Technologies

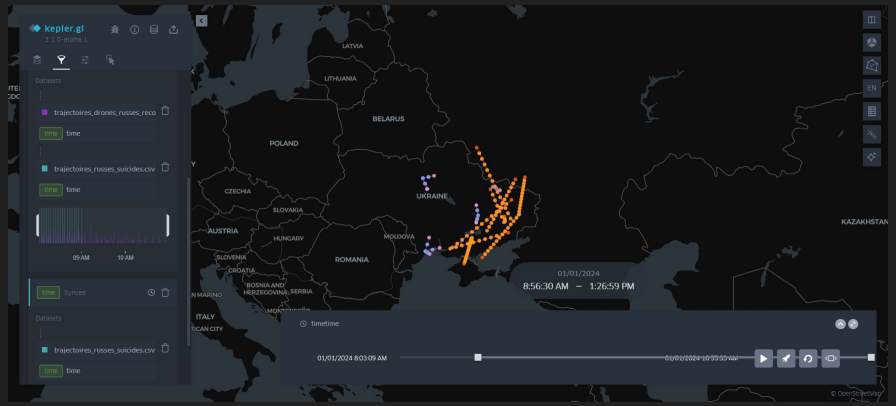
Location of russian air bases & ukrainian cities

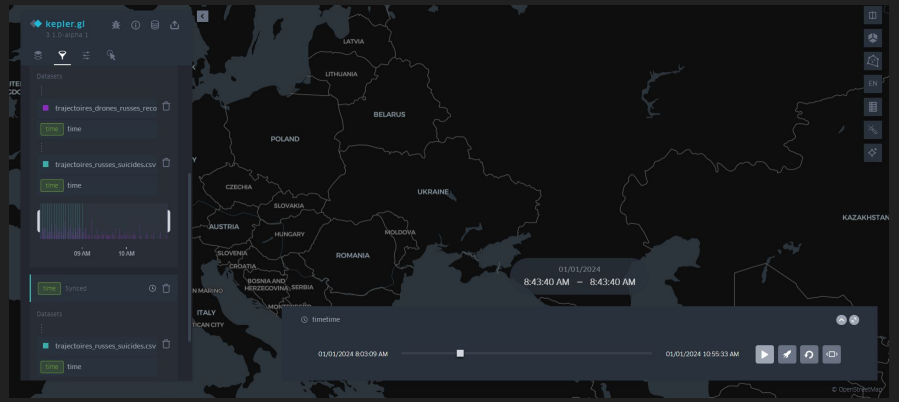


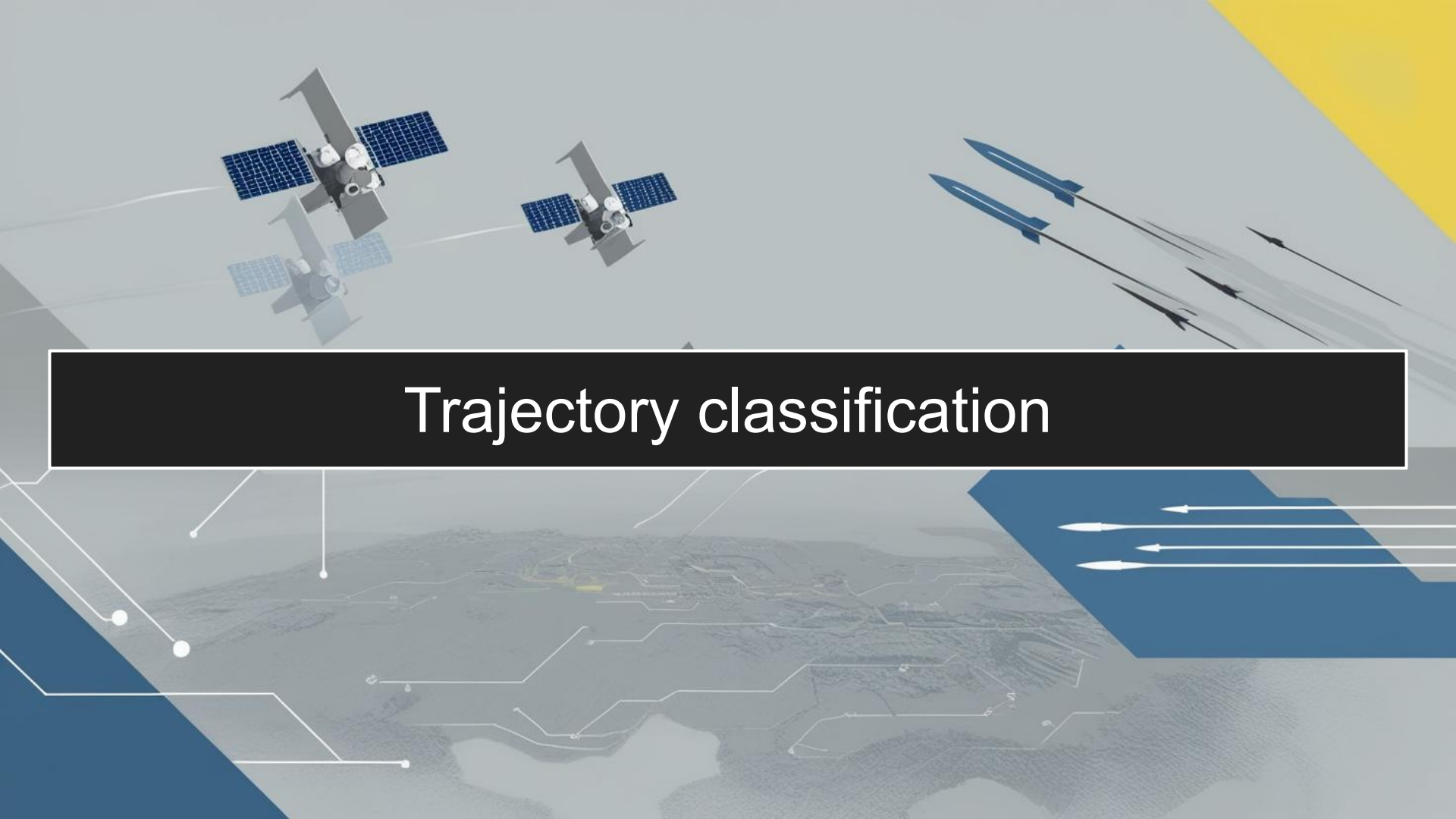
Data collected to simulate trajectories



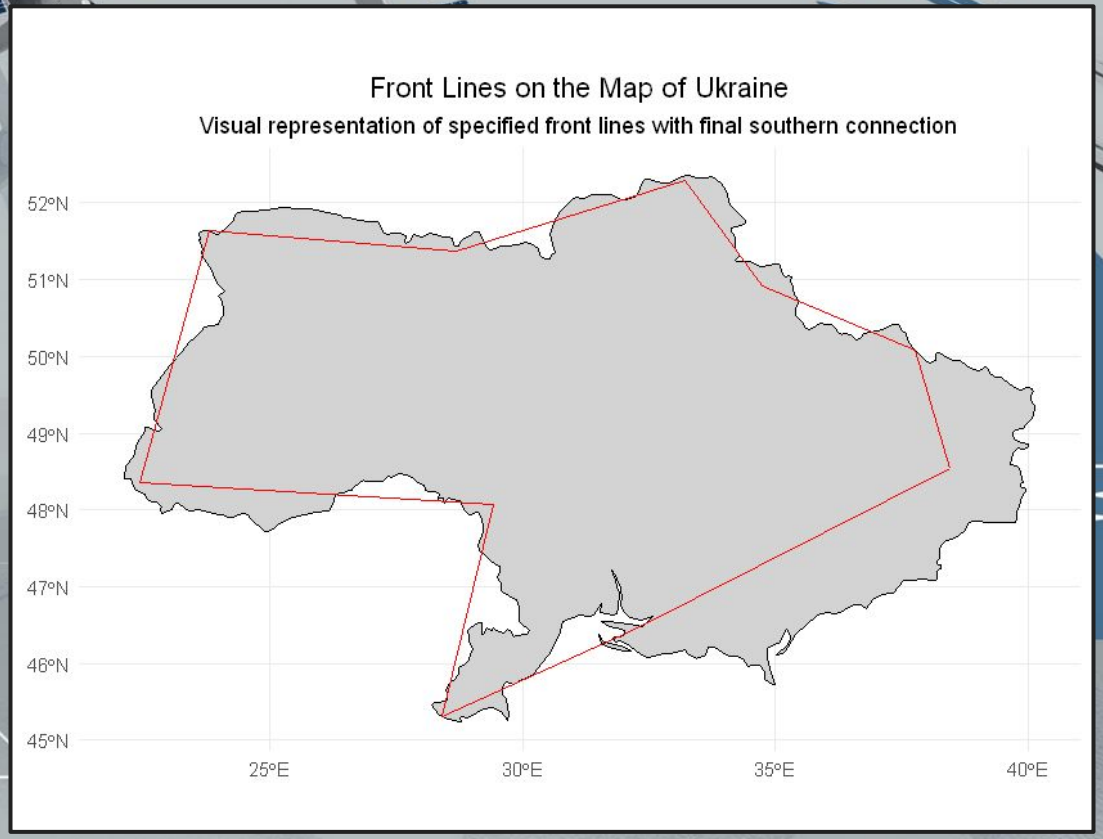


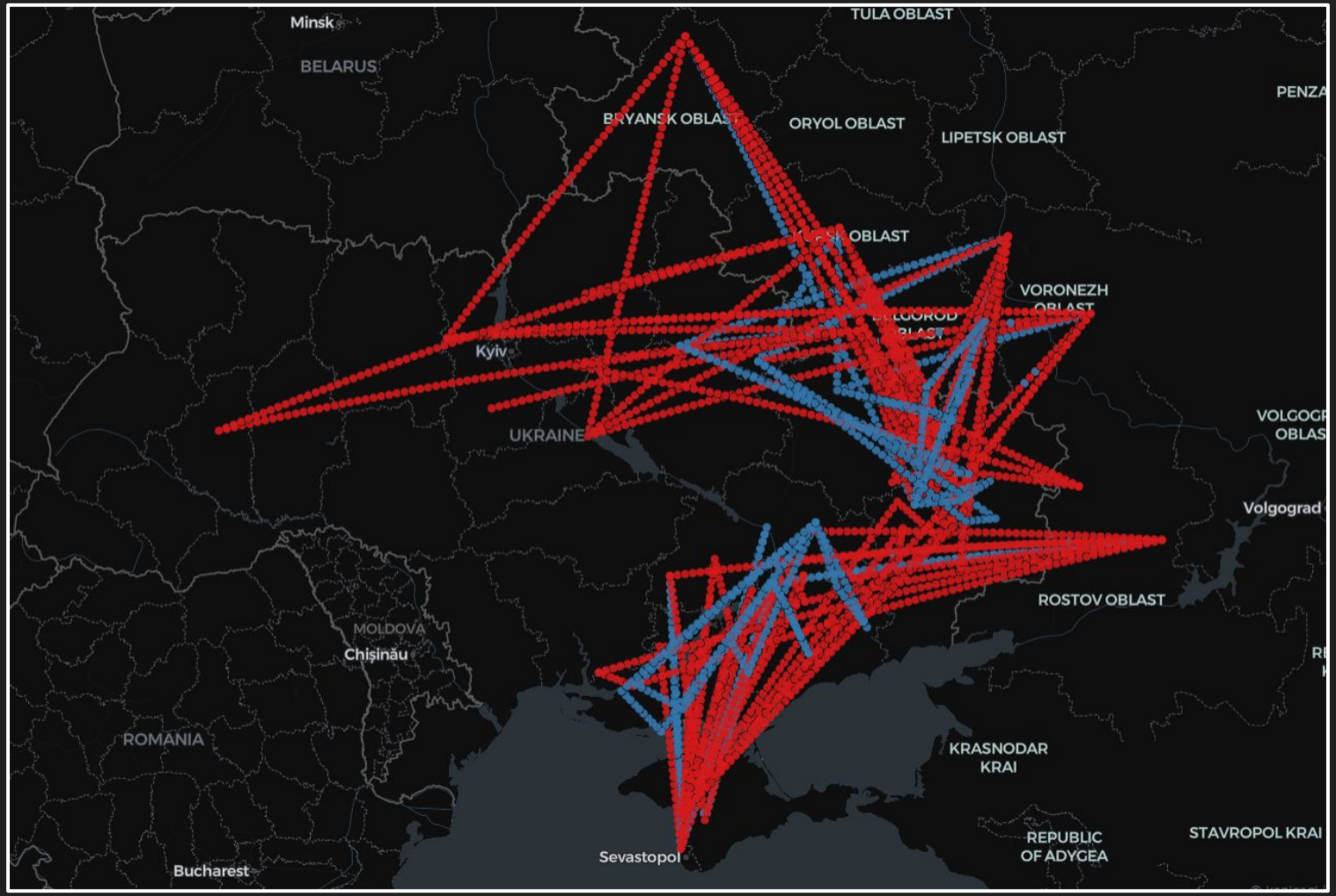





Trajectory classification

Polygon Representation

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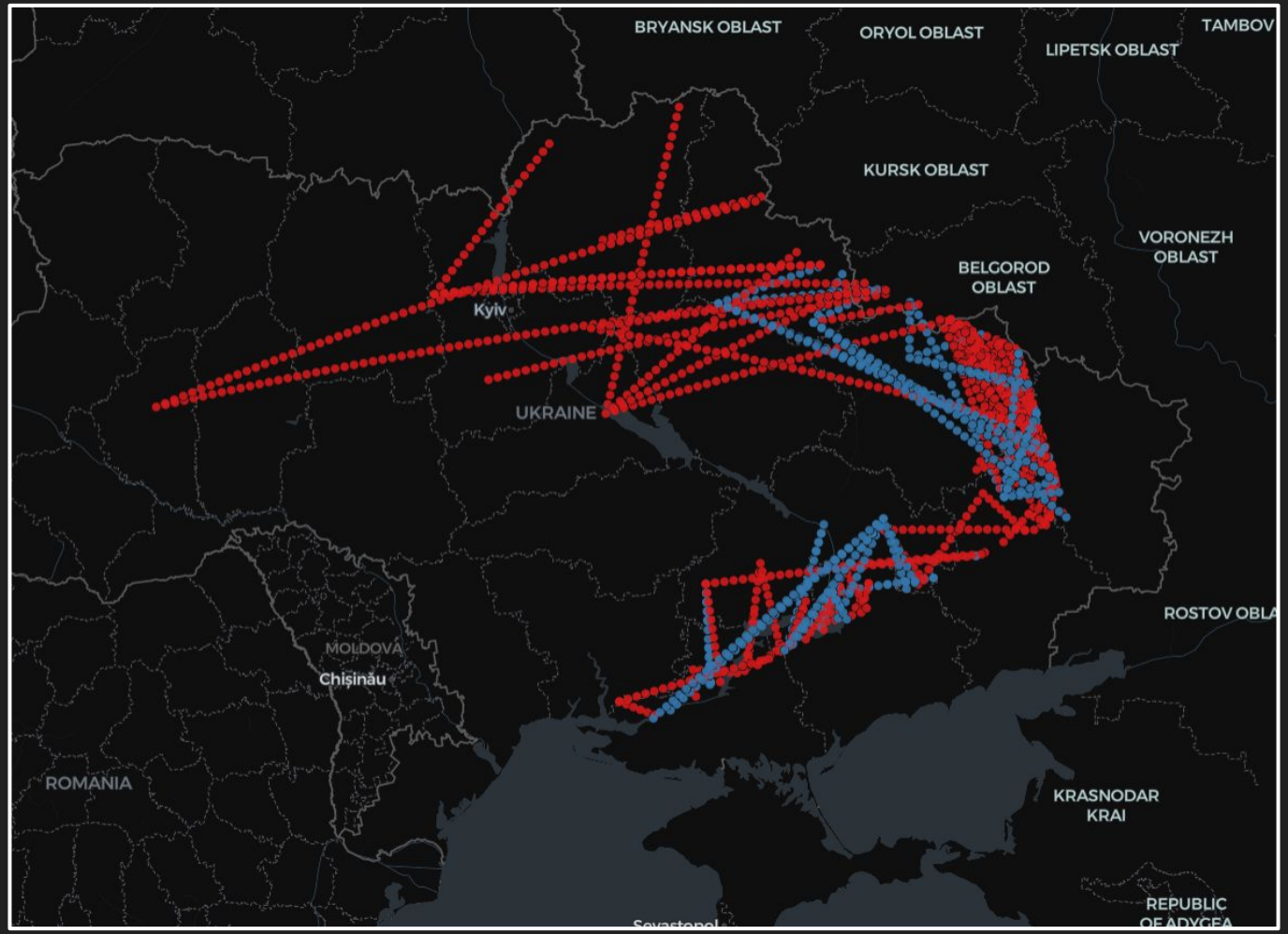
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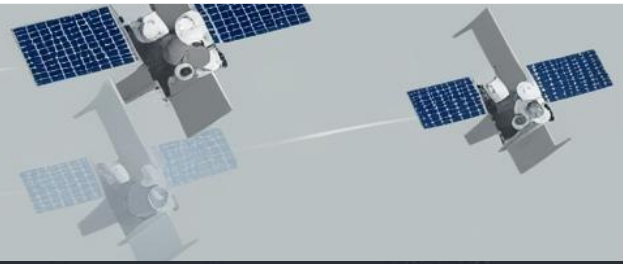
Data in entry of the Random Forest

Drone_ID	Distance_Bordure	Direction_Ukraine	Changement_Direction	Origine	Type	Vitesse	Altitude
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
Drone_1	101042.5147	0	0	0	1	88.31158	340.8203
Drone_10	32442.7783	0	1	0	1	89.15625	315.7651
Drone_100	45827.8101	0	0	0	0	113.98991	1560.3415
Drone_1000	101042.5147	0	1	0	0	112.08246	1598.4045
Drone_10000	3013.1170	1	1	1	1	105.51726	406.6410
Drone_1001	78690.1681	0	1	0	0	104.80268	1628.2067
Drone_1002	109.0453	1	0	1	1	101.09027	405.8906
Drone_1003	100153.2180	1	1	0	1	84.17521	327.5955
Drone_1004	2325.3114	1	1	1	1	100.05609	419.1397
Drone_1005	78690.1681	1	1	0	0	115.28863	1549.0462
Drone_1006	58367.6666	0	0	0	1	89.49440	307.9373
Drone_1007	514.5401	1	1	1	1	90.84235	402.8118

Result of the classification (Random Forest)



Importance des variables pour Origine

	0	1
Distance_Bordure	23.5249438	55.4373941
Direction_Ukraine	1.0796130	1.0030214
Changement_Direction	0.9812603	0.5608878
Vitesse	4.7618314	2.5765822
Altitude	5.6184370	7.3697696

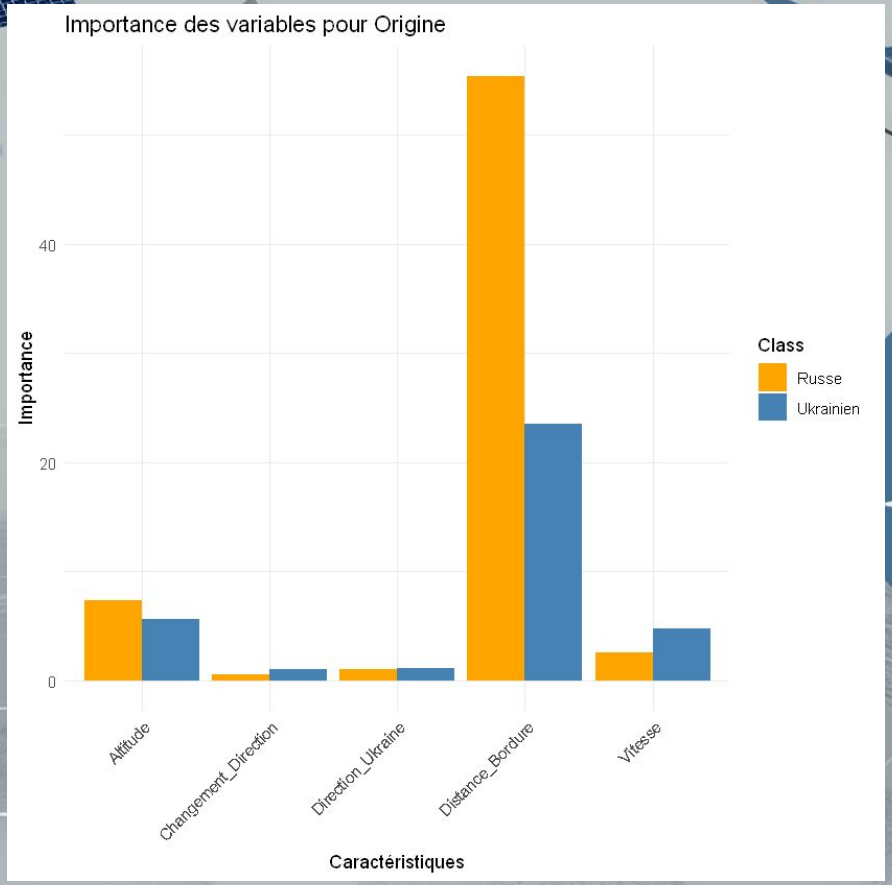
Évaluation du modèle pour Origine
Confusion Matrix and Statistics

Prediction \ Reference	0	1
0	937	0
1	0	1050

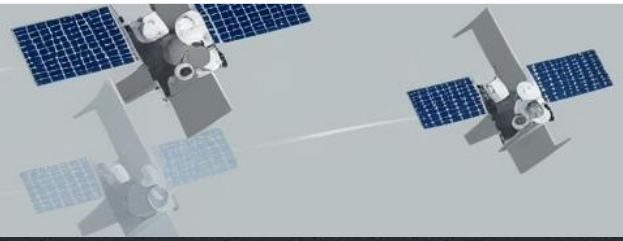
Accuracy	1
95% CI	(0.9981, 1)
No Information Rate	0.5284
P-Value [Acc > NIR]	< 2.2e-16
Kappa	1
Mcnemar's Test P-Value	NA
Sensitivity	1.0000
Specificity	1.0000
Pos Pred Value	1.0000
Neg Pred Value	1.0000
Prevalence	0.4716
Detection Rate	0.4716
Detection Prevalence	0.4716
Balanced Accuracy	1.0000

'Positive' Class : 0

Result of the classification for Drone Origin



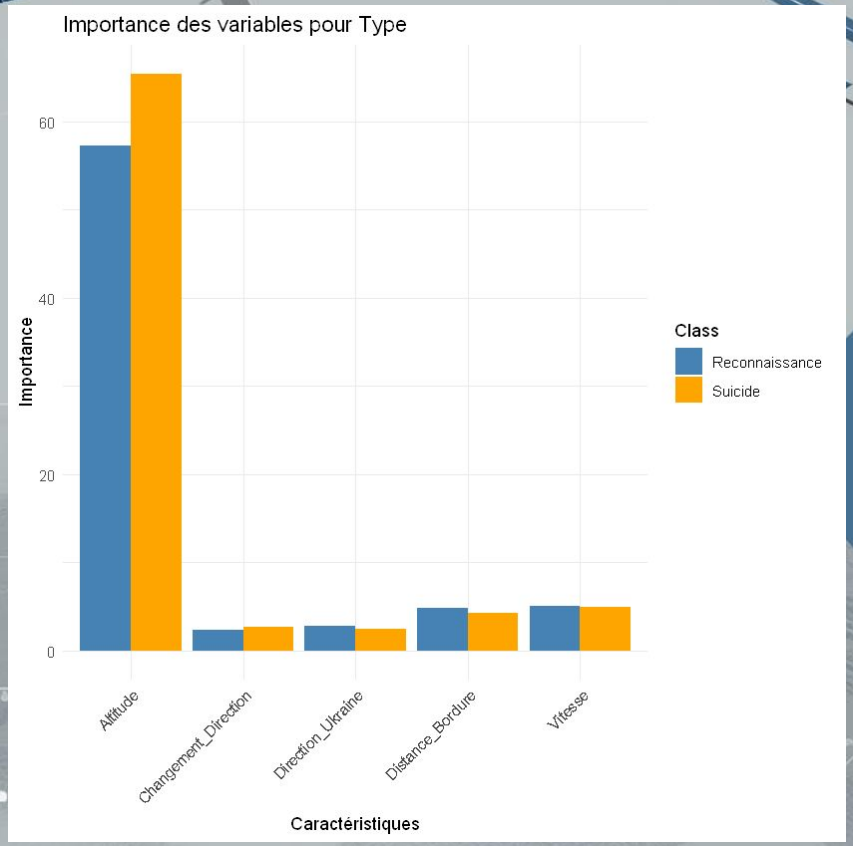
Result of the classification (Random Forest)




```
### Importance des variables pour Type ##
                            0         1
Distance_Bordure     3.909634  4.902013
Direction_Ukraine    2.629684  2.919387
Changement_Direction 2.212913  2.802464
Premiere_Appearance  2.922433  3.298552
Vitesse              5.367764  6.341884
Altitude            36.268943 39.644906
```

```
### Évaluation du modèle pour Type ###
Confusion Matrix and Statistics

          Reference
Prediction   0   1
         0 991   0
         1   0 996

               Accuracy : 1
                 95% CI : (0.9981, 1)
    No Information Rate : 0.5013
    P-Value [Acc > NIR] : < 2.2e-16

                  Kappa : 1

 Mcnemar's Test P-Value : NA

            Sensitivity : 1.0000
            Specificity : 1.0000
         Pos Pred Value : 1.0000
         Neg Pred Value : 1.0000
             Prevalence : 0.4987
         Detection Rate : 0.4987
   Detection Prevalence : 0.4987
      Balanced Accuracy : 1.0000

       'Positive' Class : 0
```

Result of the classification for Drone Type



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