SDC Assignment 3 - EKF/UKF fusion

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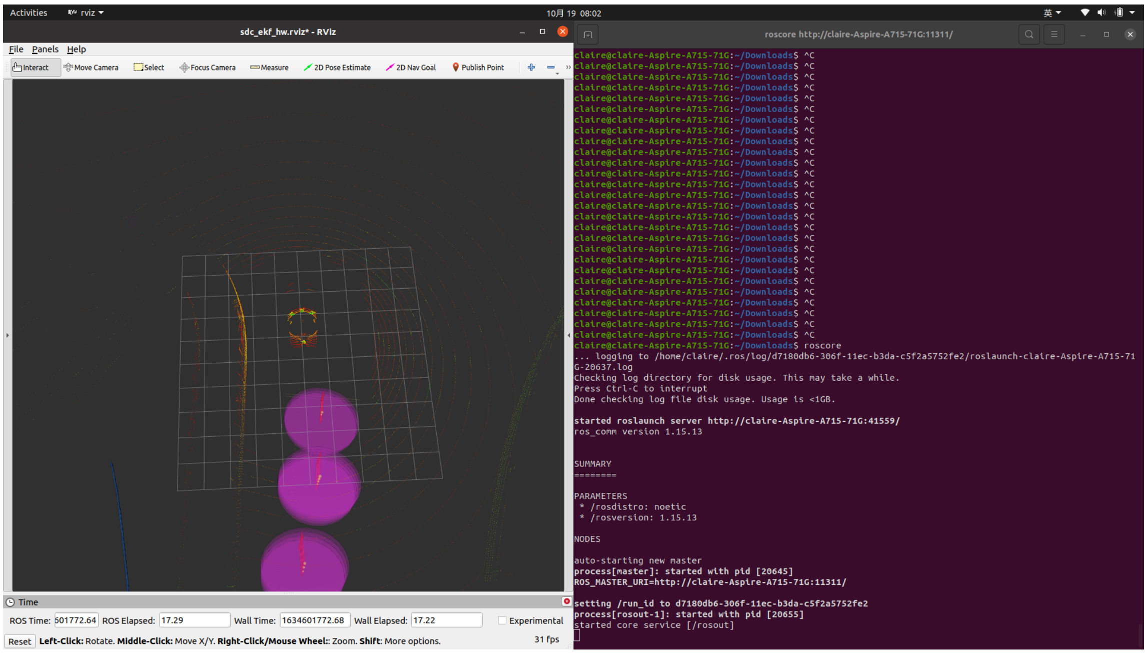
- **Result**

1. only GPS



ROS Time: 501772.64 ROS Elapsed: 17.29 Wall Time: 1634601772.68 Wall Elapsed: 17.22

```
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
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claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ ^C
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/d7180db6-306f-11ec-b3da-c5f2a5752fe2/roslaunch-claire-Aspire-A715-71
G-20637.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:41559/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [20645]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to d7180db6-306f-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [20655]
started core service [/rosout]
```
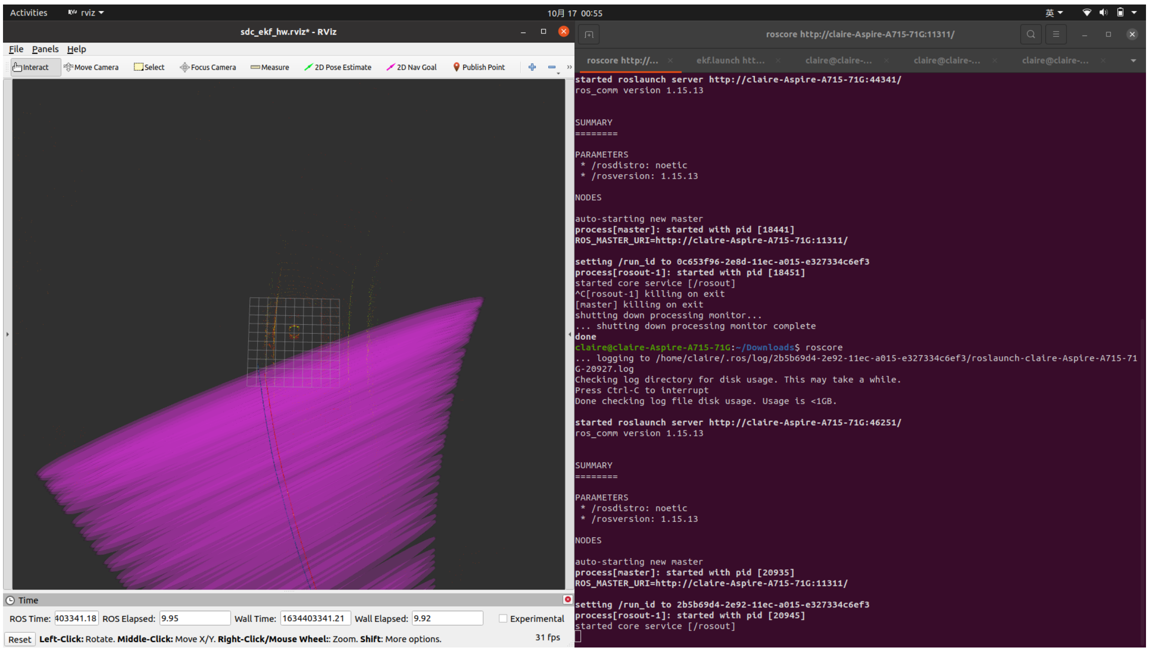
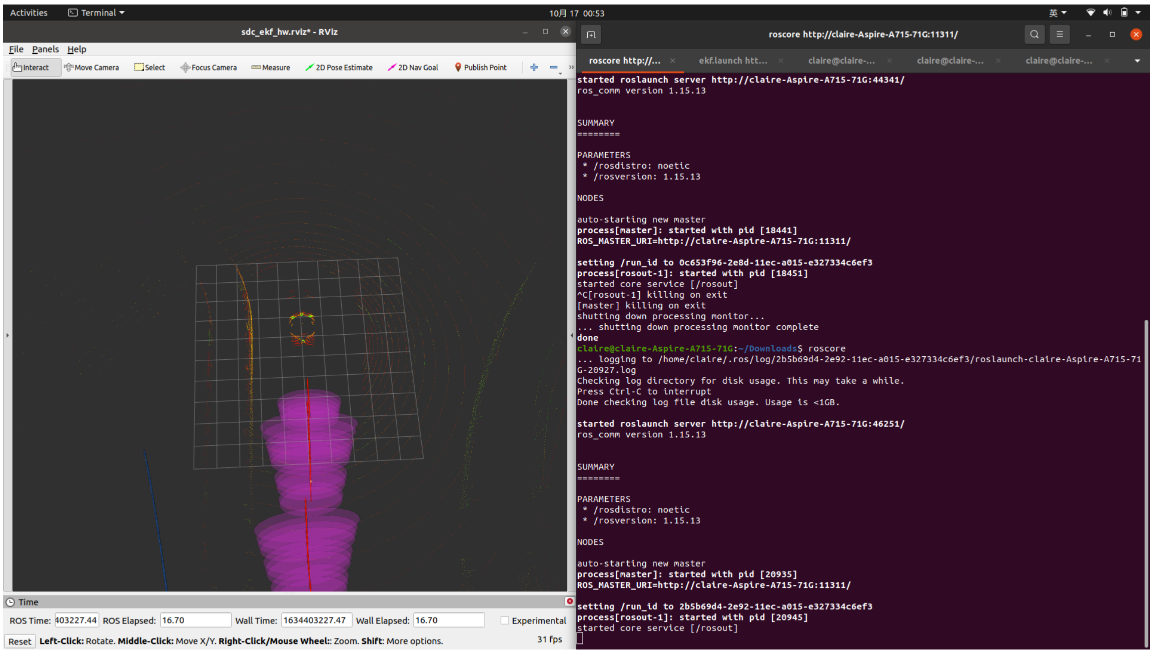

2. only radar odemetry



ROS Time: 403341.18 ROS Elapsed: 9.95 Wall Time: 1634403341.21 Wall Elapsed: 9.92

```
started roslaunch server http://claire-Aspire-A715-71G:44341/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [18441]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 0c653f96-2e8d-11ec-a015-e327334c6ef3
process[rosout-1]: started with pid [18451]
started core service [/rosout]
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/2b5b69d4-2e92-11ec-a015-e327334c6ef3/roslaunch-claire-Aspire-A715-71
G-20927.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:46251/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [20935]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 2b5b69d4-2e92-11ec-a015-e327334c6ef3
process[rosout-1]: started with pid [20945]
started core service [/rosout]
```

3. both GPS and radar odemetry



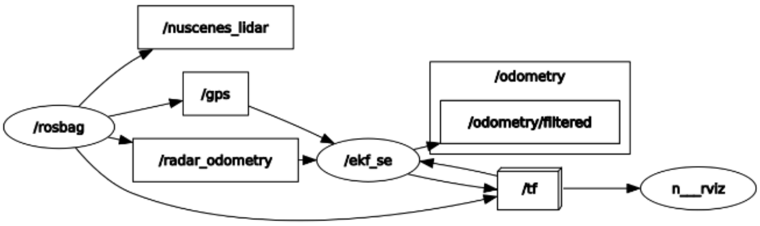
ROS Time: 403227.44 ROS Elapsed: 16.70 Wall Time: 1634403227.47 Wall Elapsed: 16.70 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

```
started roslaunch server http://claire-Aspire-A715-71G:44341/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [18441]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 0c653f96-2e8d-11ec-a015-e327334c6ef3
process[rosout-1]: started with pid [18451]
started core service [/rosout]
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/2b5b69d4-2e92-11ec-a015-e327334c6ef3/roslaunch-claire-Aspire-A715-71
G-20927.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:46251/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [20935]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 2b5b69d4-2e92-11ec-a015-e327334c6ef3
process[rosout-1]: started with pid [20945]
started core service [/rosout]
```

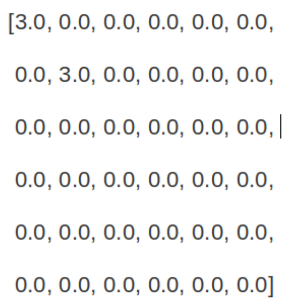
- ## Discussion

1. How do robot_localization package know the **covariance matrix** of GPS and radar odometry?



We assign the right topic which has been published by the rosbag to the sensor parameter of the ekf_localization_node, so the robot_localization package can know the covariance matrix of GPS and radar odometry from those topics which has the information of covariance matrix.

2. What is the covariance matrix of GPS and what does it mean?
The covariance matrix of GPS:



```
[3.0, 0.0, 0.0, 0.0, 0.0, 0.0,
 0.0, 3.0, 0.0, 0.0, 0.0, 0.0,
 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
```

A covariance matrix is a square matrix giving the covariance between each pair of elements of a given random vector, and its main diagonal contains variances (i.e., the covariance of each element with itself). A pose information contains 6 variables that are X, Y, Z, roll, pitch, yaw, and the GPS here only provides x,y position. So, there are only first two elements on main diagonal is non-zero value.

3. In the yaml file, do you set differential parameter of odometry and GPS to **true**? or **false**? Why?

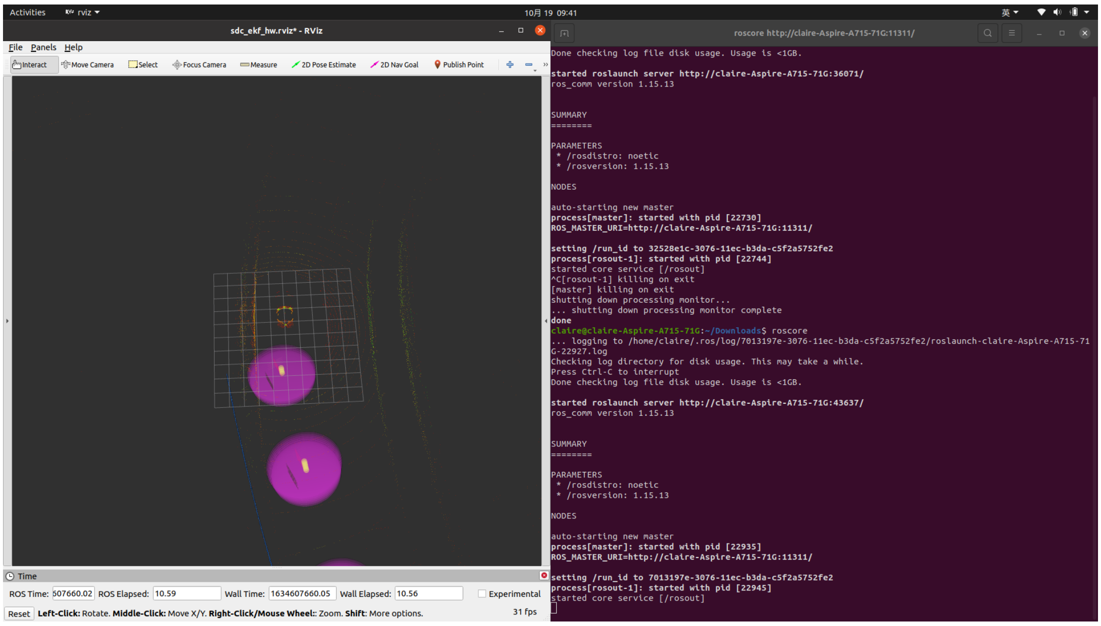
   I set the differential parameter of odometry to true, and the parameter of GPS to false. The function of this differential parameter is to infer velocity from position, and fuse that velocity instead. If we have two pose inputs that measure the same variable, but they diverge from each other, we can use the parameter to force one of them to be treated as a velocity, which will keep the filter's pose output from oscillating. The GPS is an absolute position sensor, and enabling differential integration defeats the purpose of using it. Thus, I do such setting above.

- ## Bonus

Discussion:

By comparing the EKF result with the UKF result, I found that the effect of two filters are similar, but I think UKF is a little better. The filtered result of UKF updates faster than the EKF filter because the UKF filter doesn’t need to calculate the Jacobian matrix that the computing speed is faster. However, the method of UKF would fail after starting a while in the case of using only radar odemetry.

1. only GPS

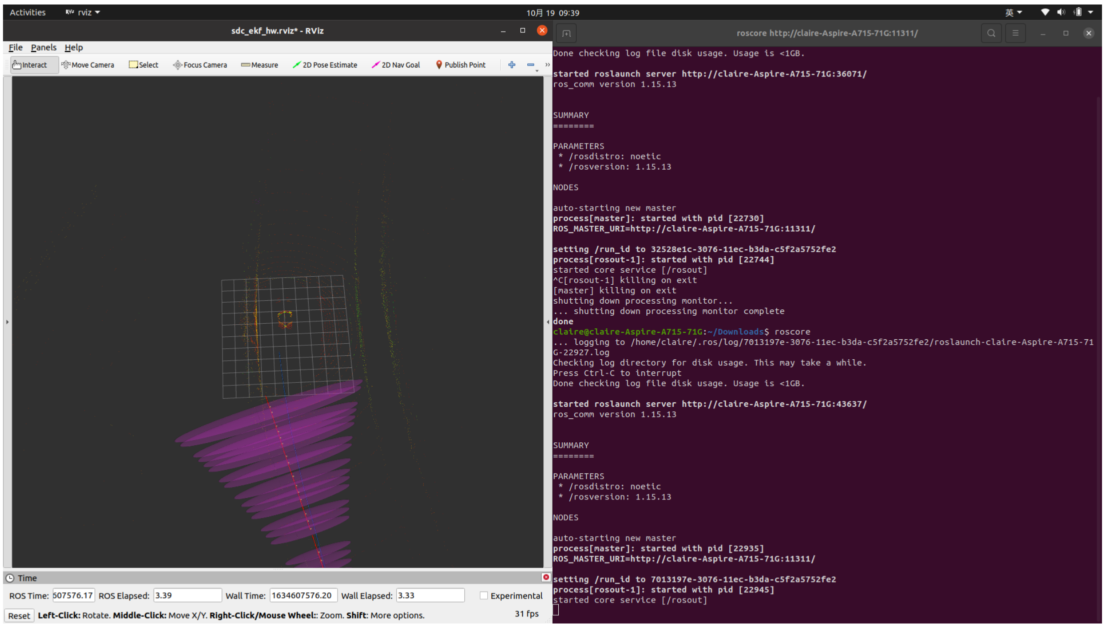


ROS Time: 507660.02 ROS Elapsed: 10.59 Wall Time: 1634607660.05 Wall Elapsed: 10.56 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

```
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:36071/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22730]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 32528e1c-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22744]
started core service [/rosout]
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/7013197e-3076-11ec-b3da-c5f2a5752fe2/roslaunch-claire-Aspire-A715-71
G-22927.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:43637/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22935]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 7013197e-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22945]
started core service [/rosout]
```

2. only radar odemetry

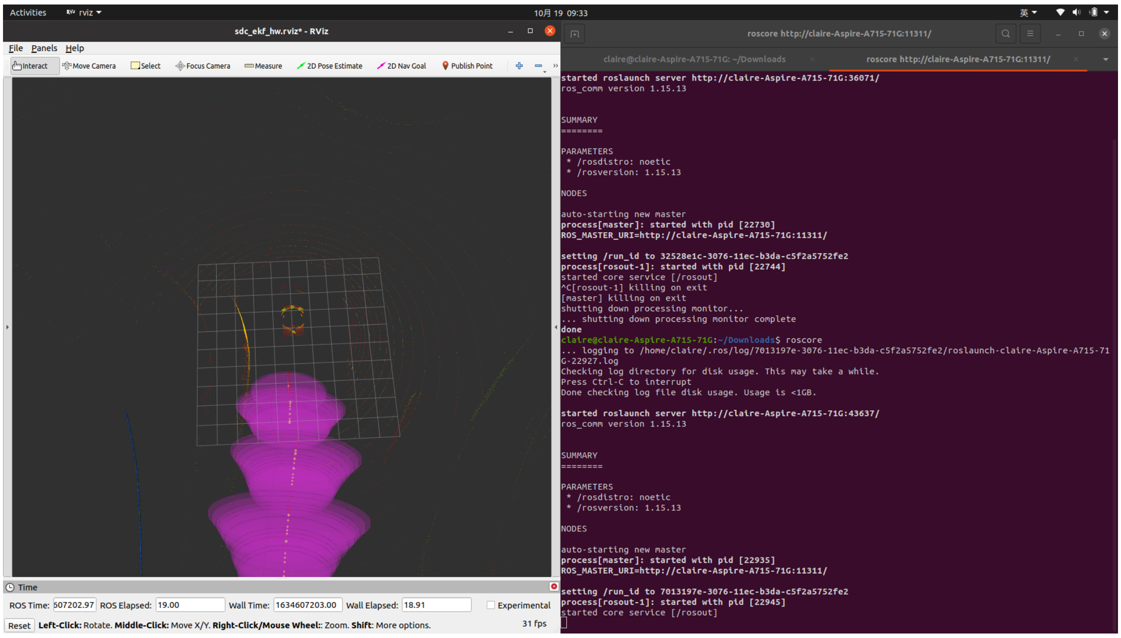


ROS Time: 507576.17 ROS Elapsed: 3.39 Wall Time: 1634607576.20 Wall Elapsed: 3.33 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

```
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:36071/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22730]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 32528e1c-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22744]
started core service [/rosout]
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/7013197e-3076-11ec-b3da-c5f2a5752fe2/roslaunch-claire-Aspire-A715-71
G-22927.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:43637/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22935]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 7013197e-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22945]
started core service [/rosout]
```

3. both GPS and radar odemetry



ROS Time: 607202.97 ROS Elapsed: 19.00 Wall Time: 1634607203.00 Wall Elapsed: 18.91 □ Experimental

Left-Click: Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

```
started roslaunch server http://claire-Aspire-A715-71G:36071/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22730]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 32528e1c-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22744]
started core service [/rosout]
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
claire@claire-Aspire-A715-71G:~/Downloads$ roscore
... logging to /home/claire/.ros/log/7013197e-3076-11ec-b3da-c5f2a5752fe2/roslaunch-claire-Aspire-A715-71
G-22927.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://claire-Aspire-A715-71G:43637/
ros_comm version 1.15.13


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.13

NODES

auto-starting new master
process[master]: started with pid [22935]
ROS_MASTER_URI=http://claire-Aspire-A715-71G:11311/

setting /run_id to 7013197e-3076-11ec-b3da-c5f2a5752fe2
process[rosout-1]: started with pid [22945]
started core service [/rosout]
```