KORUS-AQ Flight Summaries

These flight summaries have been created to provide basic context for the analysis and discussion of flight data.
Each flight day is summarized with the information described below.

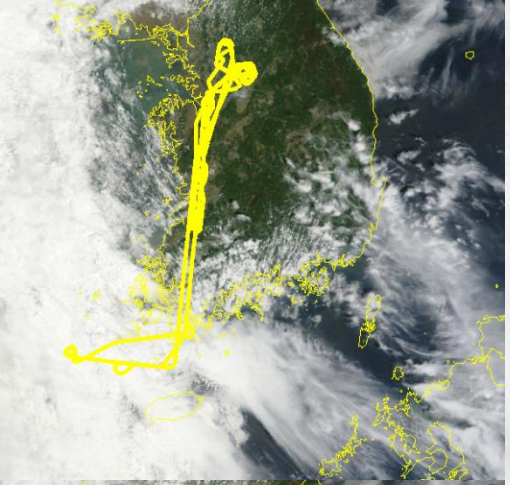
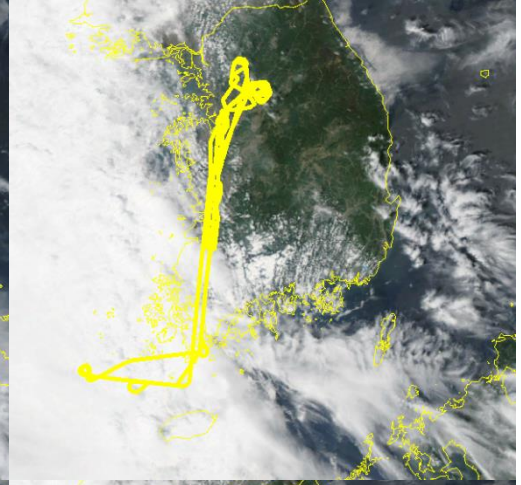
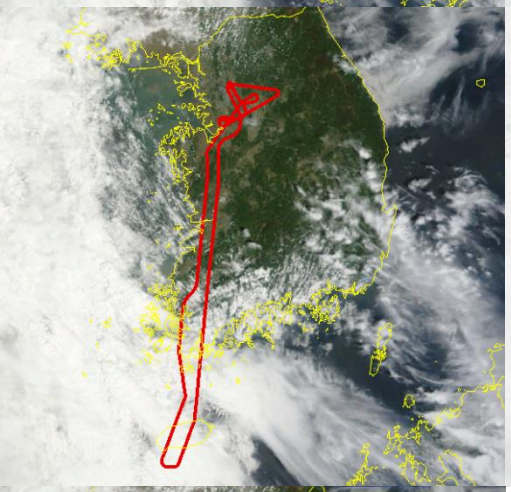
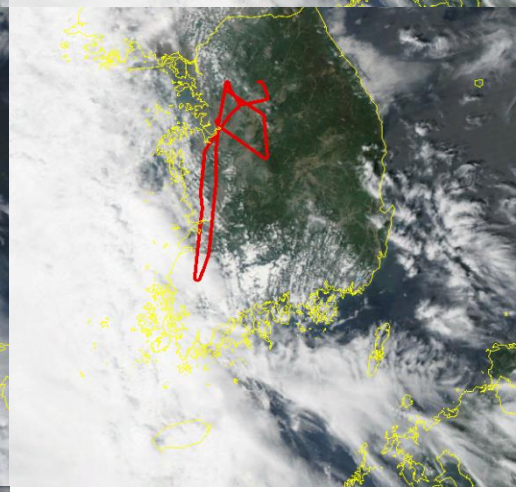
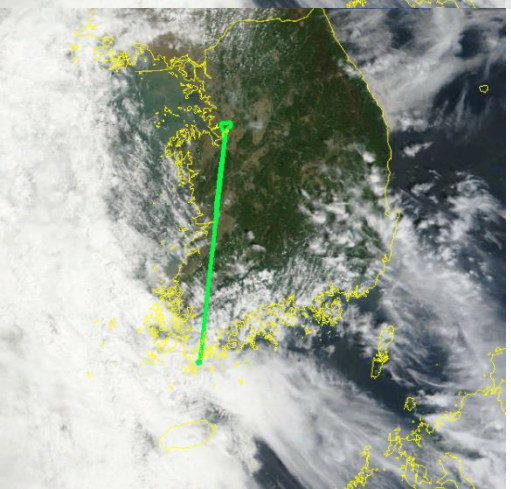
Flight graphics and cloud conditions: Images on the left-hand side of each page are from the MODIS Terra (AM) and Aqua (PM) visible satellite images, providing two snapshots of cloud coverage. These images are overlaid by flight tracks from each aircraft. The DC-8 (yellow) flight for the day is plotted on both images. For the NASA King Air (red) and Hanseo King Air (green), morning and afternoon flights are plotted on the AM or PM image as appropriate.

Flight Discussion: On the right-hand side of the page, a title provides the local date and description for each flight along with a narrative description of the following items:

Setting – The basic meteorological conditions and factors influencing the flight plan

Flight objectives – Flight maneuvers planned by each aircraft

Notes – Information on deviations from the planned flight maneuvers. Since impressions from the data collected during flight are often incomplete or misleading, discussion of the observations has been avoided.

2 May (Local) – Western Peninsula (First Official Flights)

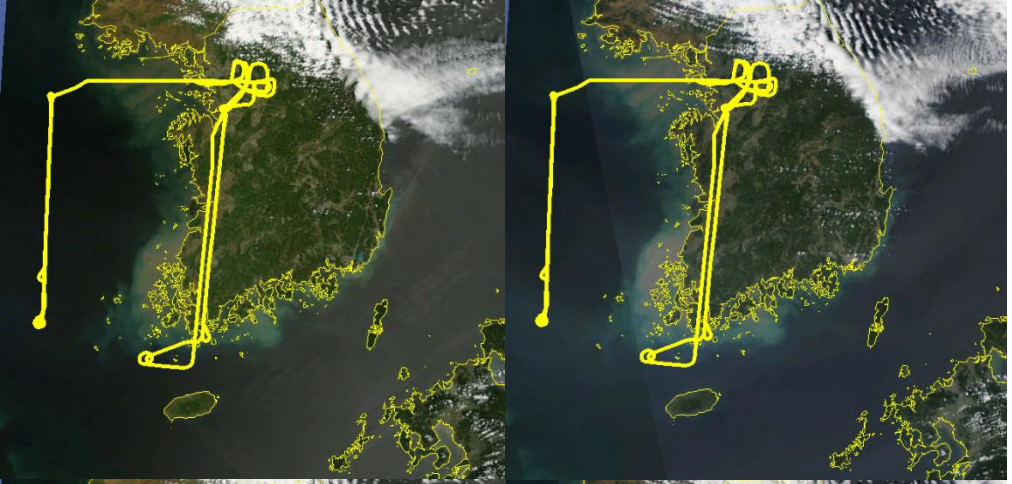
Setting: Southerly flow at surface over the peninsula and clouds offshore moving in from the southwest. Minimal transboundary influence on the Korean peninsula.

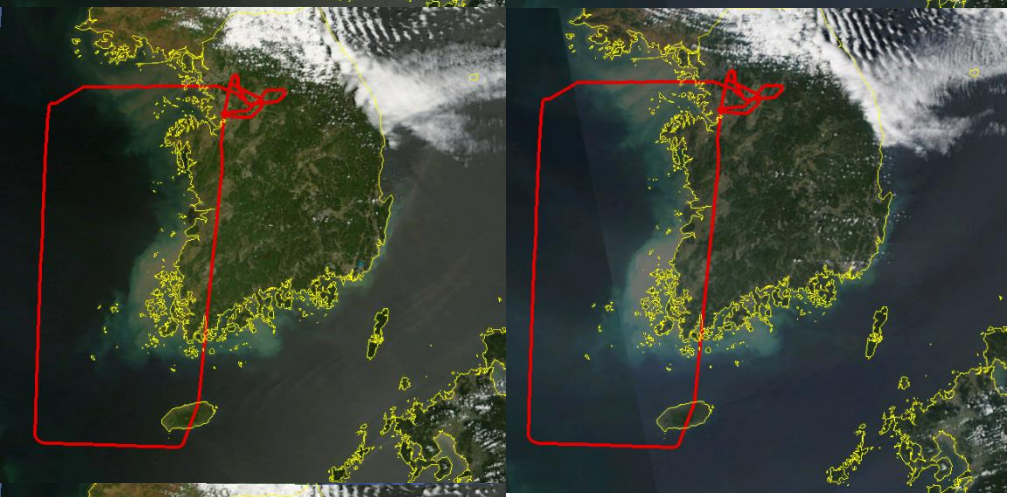
DC-8 Objectives: Demonstrate the ability to fly the Seoul-Jeju jetway at multiple altitudes in the morning and afternoon. Also execute initial attempts at overflight of Olympic Park and Taehwa with the spiral over R17 at the beginning, middle, and end of the flight.

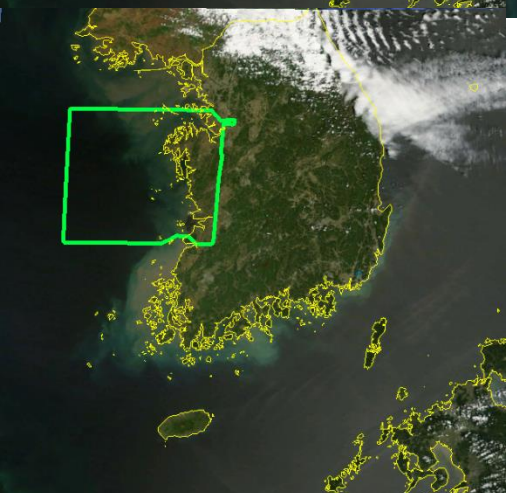
NASA King Air Objectives: Overfly the Seoul-Jeju jetway and exercise overflight of Olympic Park and Taehwa sites

Hanseo King Air Objectives: Overfly the Seoul-Jeju jetway

Notes: Clouds on southern end of flight track complicated the flight for both the DC-8 and NASA King Air, especially south of Gwangju. Vectoring of the DC-8 for the Olympic Park overflight led to an unexpected result as the plane was sent north of the Han river for a descent over eastern Seoul that passed over the ground site and terminated in a missed approach over Seoul AB. This surprising event was better than the planned maneuver, providing for a sounding of the lower atmosphere over Seoul. It was adopted as the standard maneuver for all future flights and was designated as the Seoul stereoroute.







4 May (Local) – Offshore-Onshore Sampling with weak Chinese influence

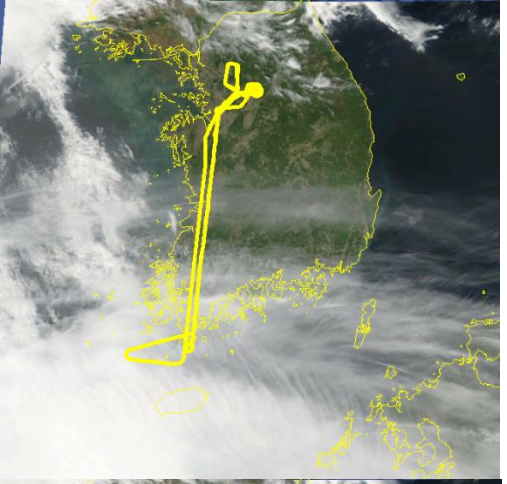
Setting: Westerly flow over the peninsula, with Chinese pollution over the West Sea, but prediction of only a weak Chinese influence on peninsula inflow. Stratospheric influence expected aloft.

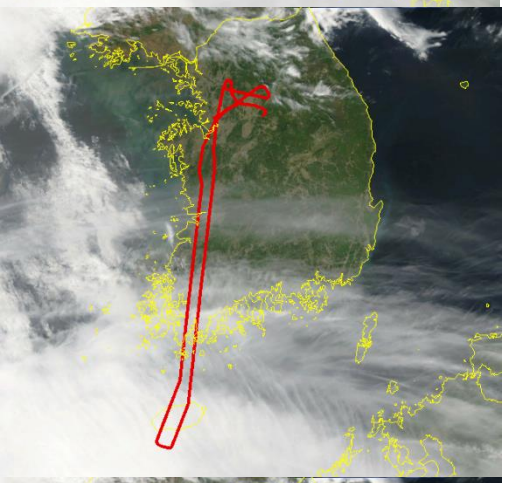
DC-8 Objectives: Fly walls over the West Sea jetway in the morning and Seoul-Jeju jetway in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

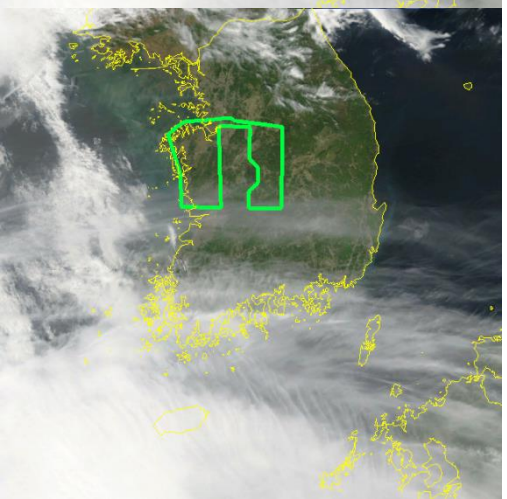
NASA King Air Objectives: Overfly the West Sea and Seoul-Jeju jetways in the morning and afternoon including overflight of the Olympic Park and Taehwa sites at the beginning and end of each sortie.

Hanseo King Air Objectives: Execute sampling along an offshore-onshore route over the northern portions of the West Sea and Seoul-Jeju jetways.

Notes: Second DC-8 spiral over Taehwa was interrupted. NASA King Air was prevented from overflying Olympic Park at the beginning of the afternoon sortie. Continued to work on communication with ATC.







5 May (Local) – Half Day Western Peninsula under the influence of dust

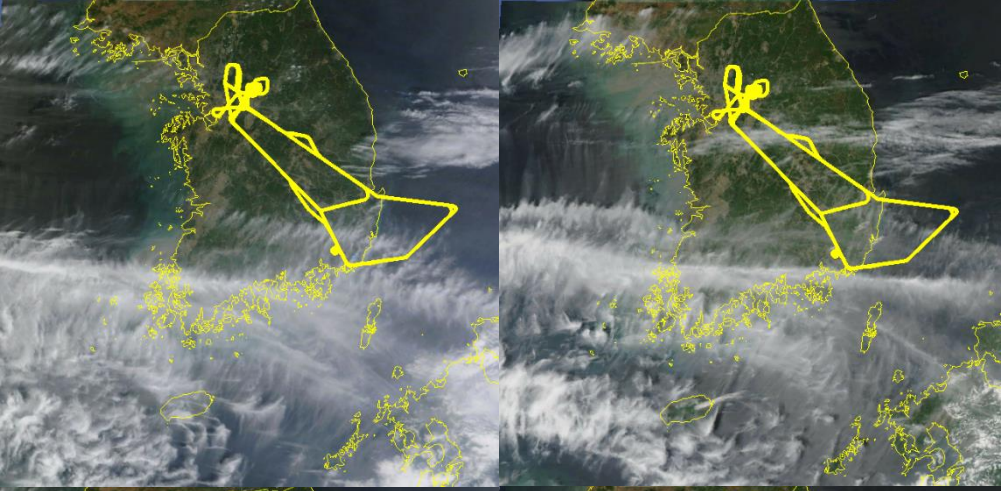
Setting: Despite impending clouds, a half day sortie was planned to take advantage of an incursion of dust over the western side of the peninsula. This provided an important opportunity to examine the impact of dust on remote sensing.

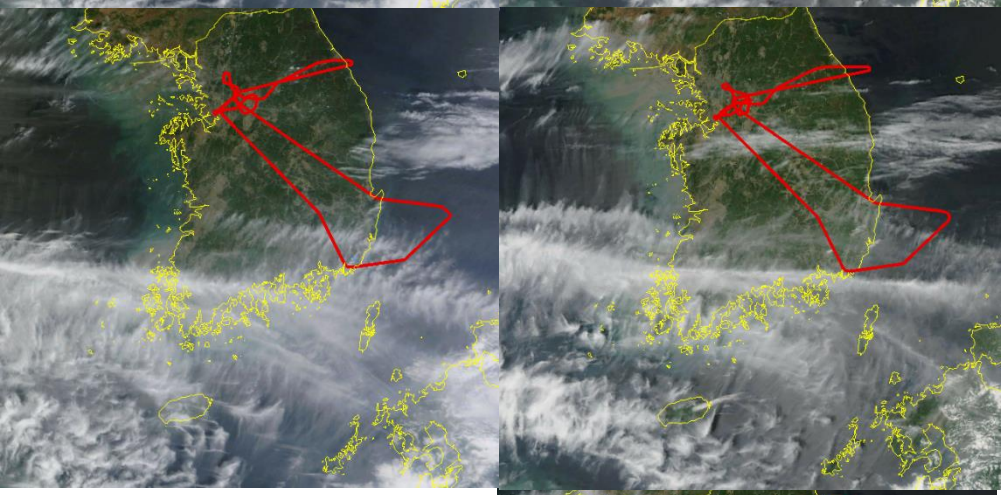
DC-8 Objectives: Fly a wall over the Seoul-Jeju jetway in morning. Also execute the Seoul stereoroute and Taehwa spiral at the beginning and end of the flight.

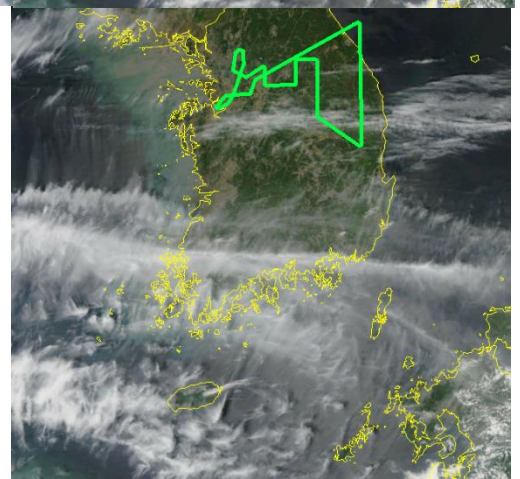
NASA King Air Objectives: Conduct one sortie to overfly the Seoul-Jeju jetway in the morning, including overflight of the Olympic Park and Taehwa sites at the beginning and end of the flight.

Hanseo King Air Objectives: Examine the dust plume by sampling across the axis of transport from west to east across the northwestern part of the peninsula.

Notes: The presence of the dust layer was verified and flights were completed with minimal impact of clouds, especially over the northern end of the track where dust influence was more prominent.







7 May (Local) – Southeast transport of emissions

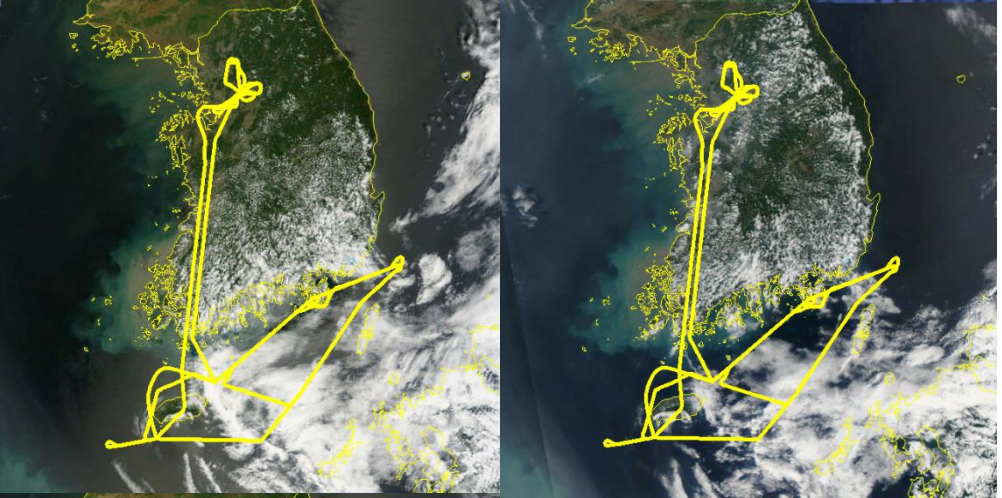
Setting: Northwesterly flow over the peninsula pushing the Seoul plume into forested areas of eastern Korea and the pollution from coastal cities in southeast Korea pushing out over the East Sea.

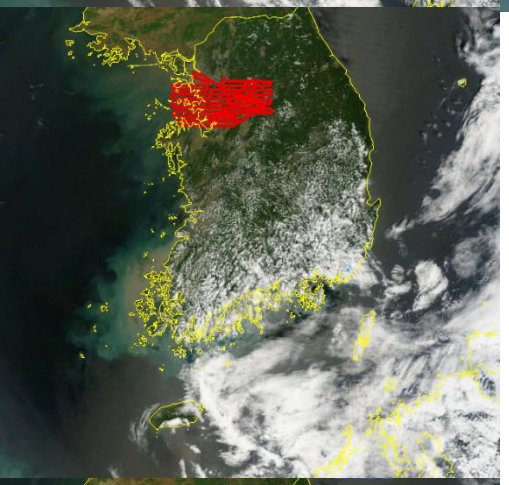
DC-8 Objectives: Fly a racetrack route at multiple altitudes along the Seoul-Busan and Seoul-Pohang jetways. Due to time constraints, the final circuit could not extend off the southeast coast. Also execute the Seoul stereoroute at the beginning, middle, and end of the flight with Taehwa spiral only at beginning and end of the flight.

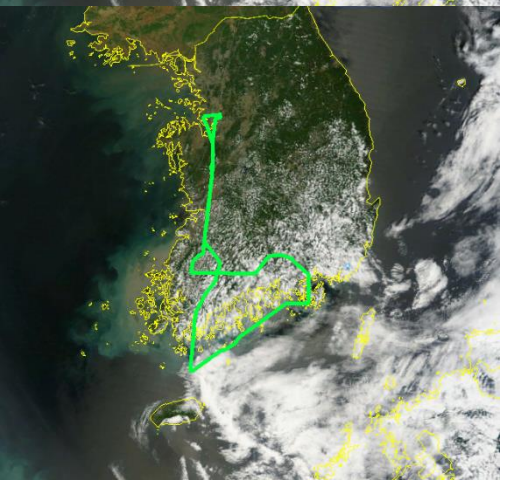
NASA King Air Objectives: Overfly the Seoul-Busan, Seoul-Pohang, Seoul-East Sea jetways in the morning and afternoon including overflight of the Olympic Park and Taehwa sites at the beginning and end of each sortie.

Hanseo King Air Objectives: Sample flow of the Seoul plume as it is transported east. Also execute the Seoul stereoroute.

Notes: King Air not allowed to overfly Olympic Park after first overflight in the morning (still trying to understand how to accomplish this maneuver consistently). Low altitude outflow of pollution plumes over the water southeast of Busan-Ulsan were a highlight.







11 May (Local) – Southern Peninsula Outflow/Seoul Raster

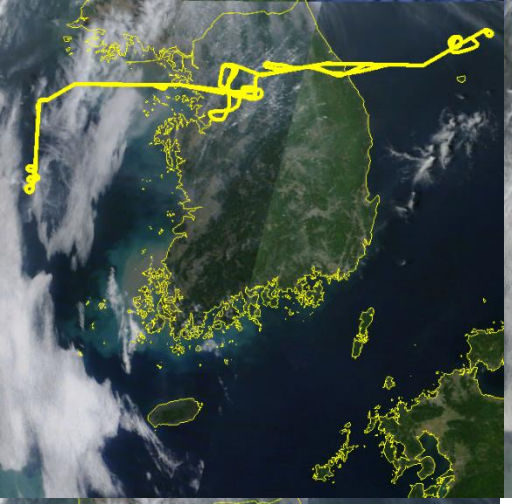
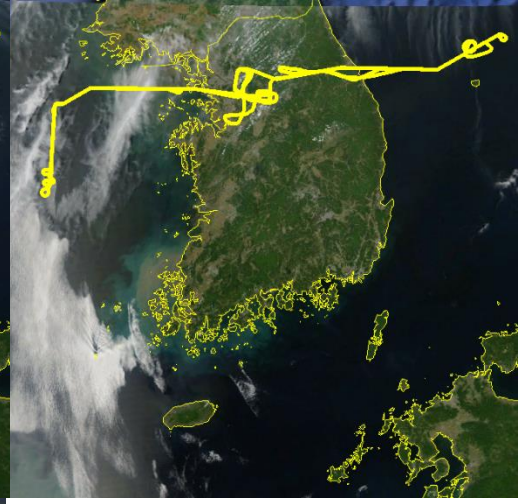
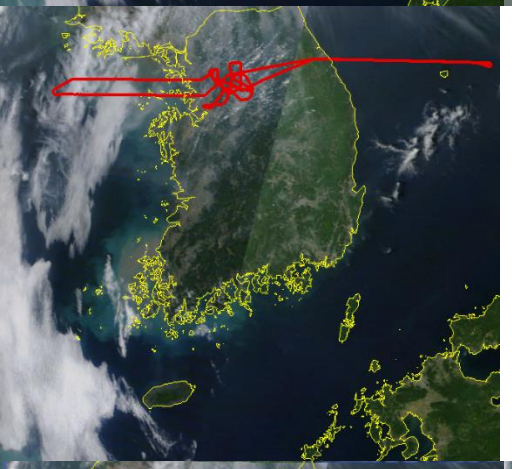
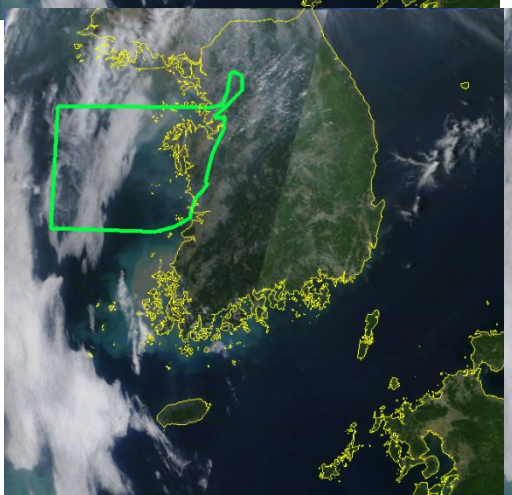
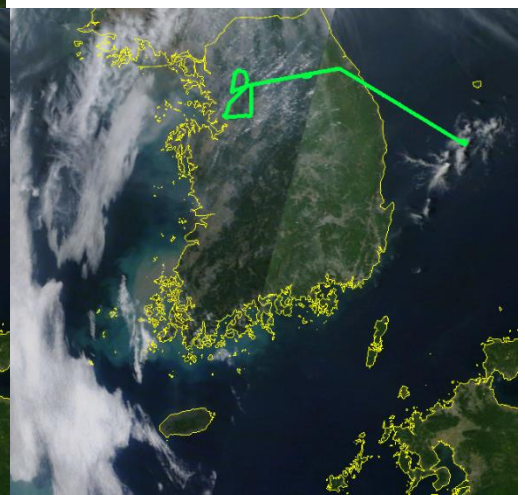
Setting: Northerly flow pushing pollution from sources on the southern coast of the peninsula offshore over the Korea strait. Stratospheric influence expected aloft.

DC-8 Objectives: Conduct sampling along the Seoul-Jeju jetway, sample extensively over the southern portion of the peninsula upwind of coastal sources and downwind at two distances. Execute the Seoul stereoroute and Taehwa spiral only at beginning and end of the flight.

NASA King Air Objectives: Raster sampling to map the Seoul Metropolitan area, taking advantage of clear skies in the north.

Hanseo King Air Objectives: Sample pollution upwind and downwind of sources on the southern coast of the peninsula.

Notes: Excessive low clouds created problems with low sampling early in the flight for the DC-8. The Hanseo King Air was more successful in executing their flight as planned. Due to delays associated with clouds, the DC-8 eliminated the plan for sampling upwind of sources on the southern coast. Pollution signatures did not present as distinct and separate plumes from different source regions as expected, possibly due to winds at 500 and 1000 feet off the south coast that were quite light and variable.

12 May (Local) – East-West/Inflow-Outflow

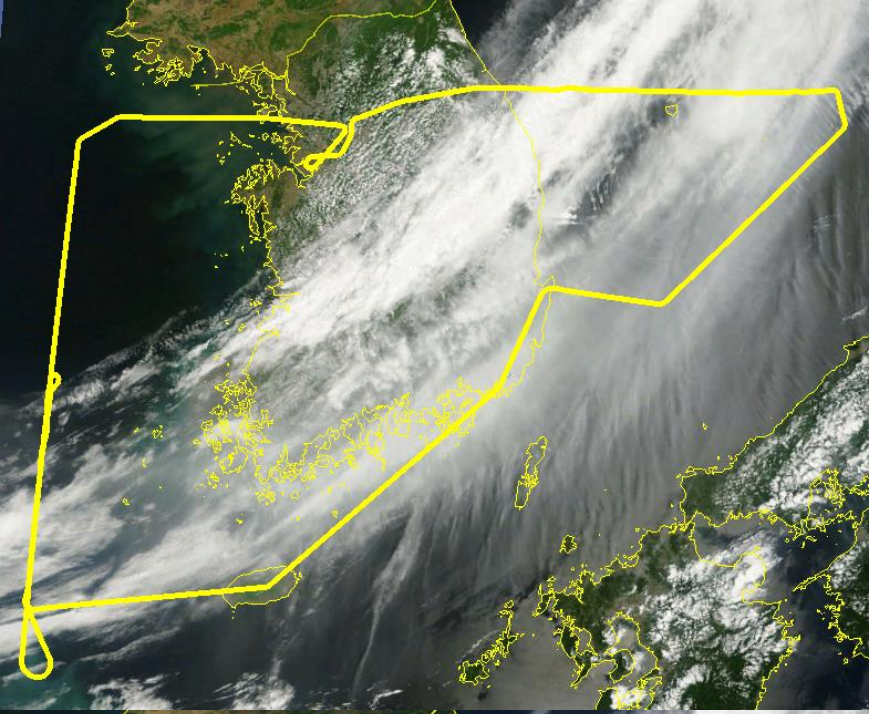
Setting: Peninsula under westerly/southwesterly flow in the lower atmosphere and westerly flow aloft with the expectation of Chinese pollution and dust transporting NE over the Yellow Sea and Korean emissions being transported to the East Sea. Some suggestion of possible biogenic emission on eastern leg over the peninsula.

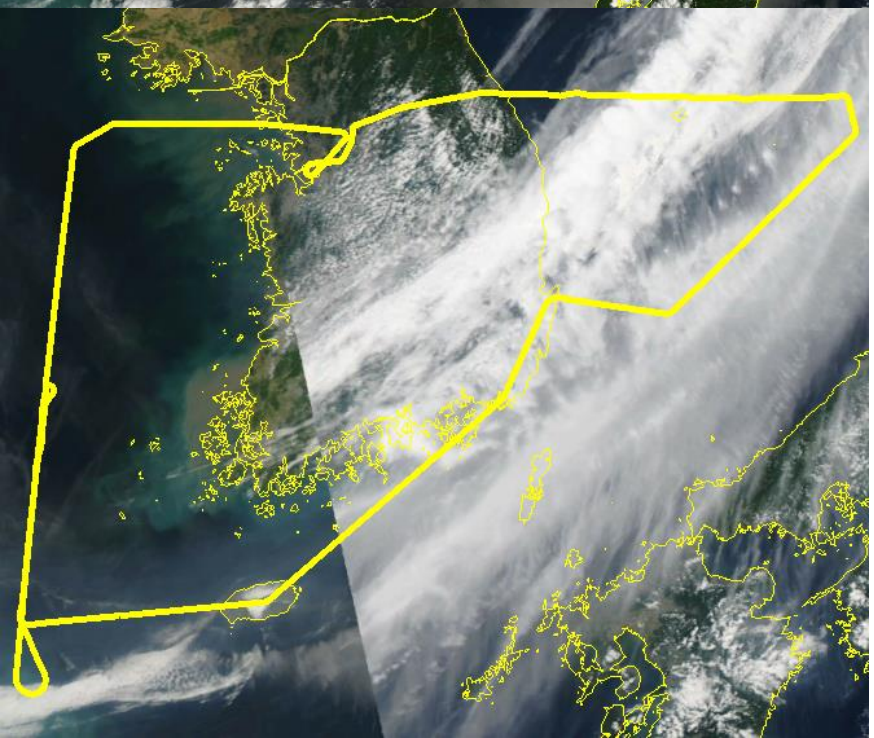
DC-8 Objectives: Conduct sampling walls to the west and east of Seoul, sampling over the West Sea in the morning and over the eastern jetway and East Sea in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: Sample over Seoul and directly to the west and east, overlapping areas sampled by the DC-8.

Hanseo King Air Objectives: Sample to the west in the morning and east in the afternoon along routes complementing the DC-8. Also execute the Seoul stereoroute on each flight.

Notes: Final missed approach for the DC-8 was limited by Seoul Approach (only down to 600 feet). Terrain on the eastern jetway posed problems for the DC-8 when trying to maintain 1000 feet AGL altitude. It was decided that this route may be more appropriate for Hanseo in the future.





13 May (Local) – Frontal Cloud Profiling

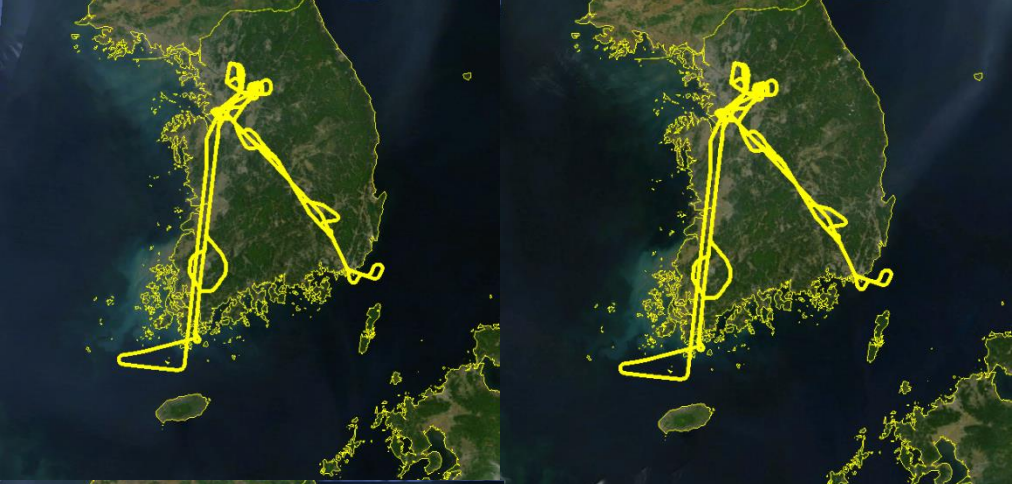
Setting: Frontal passage with cloud band centered on the Korean peninsula stretching from the southwest to the northeast.

DC-8 Objectives: Sample frontal cloud by proceeding west of the peninsula at altitude and descending through frontal cloud while heading south over the West Sea. Climbing back to altitude, proceed around the southern end of the peninsula to descend through the cloud band a second time over the East Sea before climbing to altitude and returning to base.

NASA King Air Objectives: No flight

Hanseo King Air Objectives: No flight

Notes: Slow response from ATC caused initial descent through cloud to happen late. DC-8 doubled back to climb and descend through cloud again. Due to clouds and IFR control, descent was only possible to 8000 feet. After losing time, the route to the East Sea was adjusted and it was decided to ascend through the frontal cloud from below. ATC granted permission to stay below increasing cloud cover and ascend from 500 feet through the cloud east of the peninsula before returning to base.






17 May (Local) – Local pollution survey

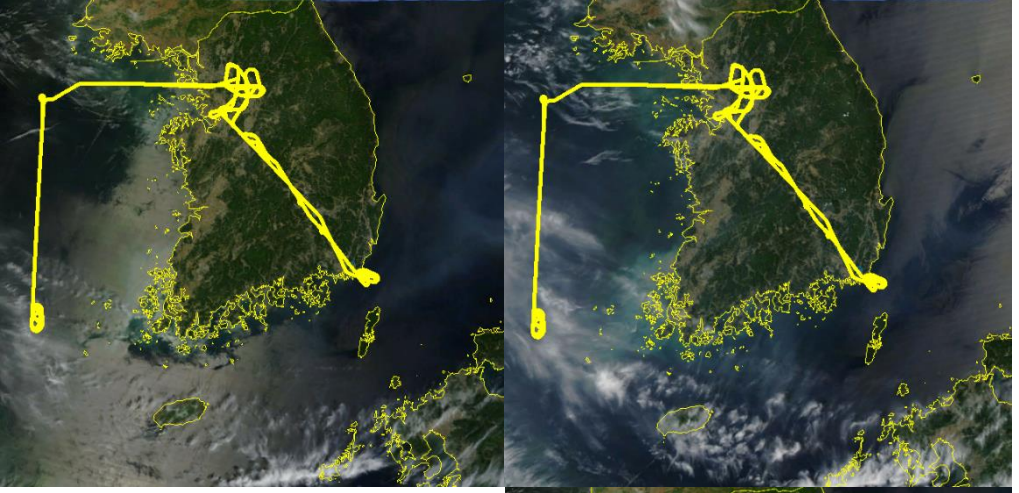
Setting: Light winds across the peninsula under high pressure with local emissions moving generally to the east, emphasizing the western peninsula under the influence of point source emissions from the west coast and the eastern peninsula entering a period of increasing temperature and the potential for increasing biogenic emissions.

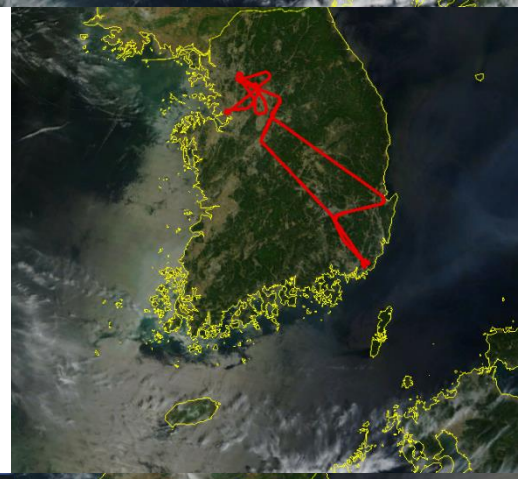
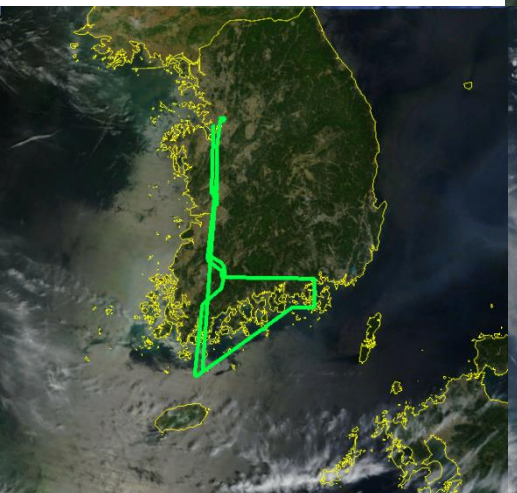
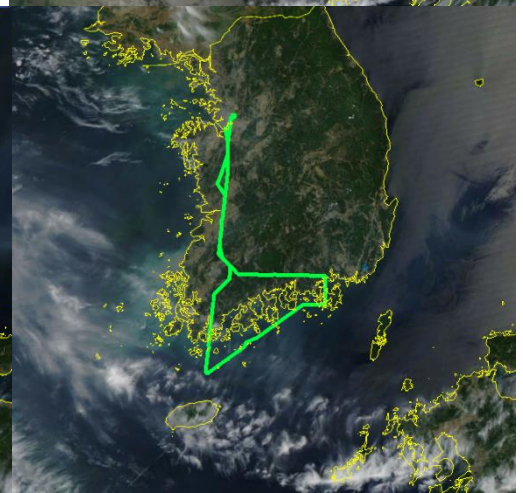
DC-8 Objectives: Conduct sampling walls along the Seoul-Jeju jetway in the morning and the Seoul-Busan jetway in the afternoon. Conduct missed approaches at Gwangju and Daegu. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: Conduct raster sampling to map the Seoul Metropolitan area in the morning and afternoon.

Hanseo King Air Objectives: Conduct sampling over the West Sea and Seoul-Jeju jetway in the morning and again over the West Sea in the afternoon. Also execute the Seoul stereoroute on each flight.

Notes: At the beginning of this flight an unintended venting of the forward lavatory on the DC-8 caused adverse effects to instruments that lingered on subsequent flights. The DC-8 experienced difficulties with the missed approach at Gwangju but succeeded at Daegu, raising questions about the value of these missed approaches versus the associated delays in executing them. Difficulties were also experienced with the descent offshore of Busan.



18 May (Local) – Offshore-onshore pollution under stagnant conditions

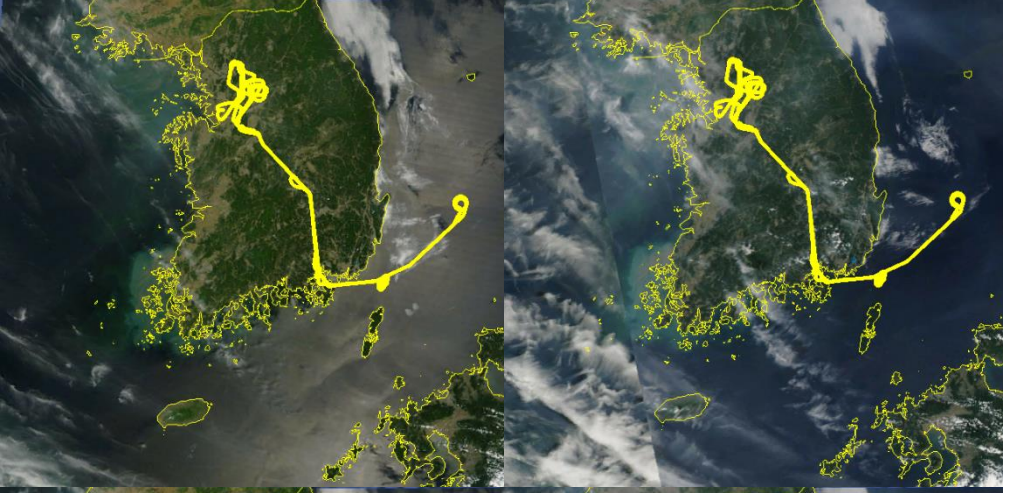
Setting: Continuation of fair conditions and stagnation across the peninsula with increasing temperatures and the expectation of increasing biogenic emissions. Chinese pollution also expected offshore over the West Sea but not moving into the peninsula.

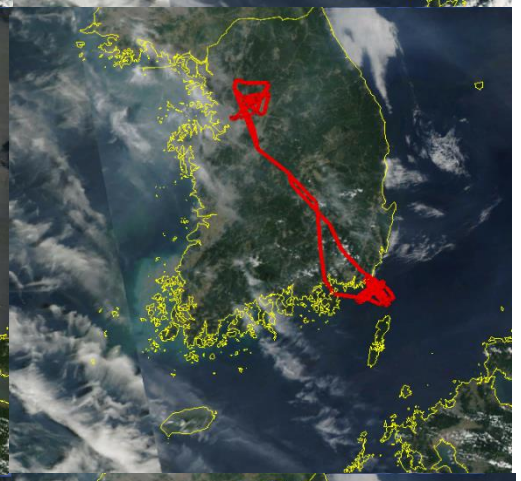
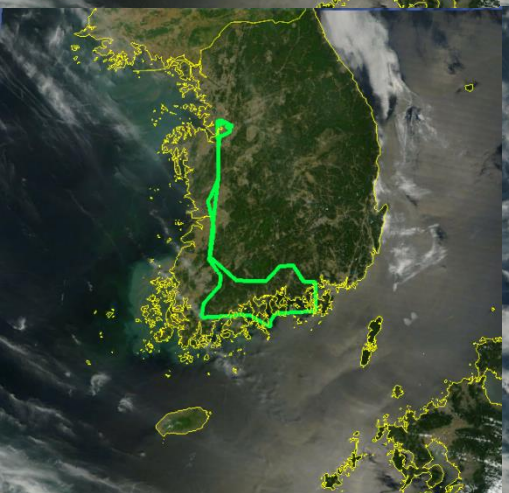
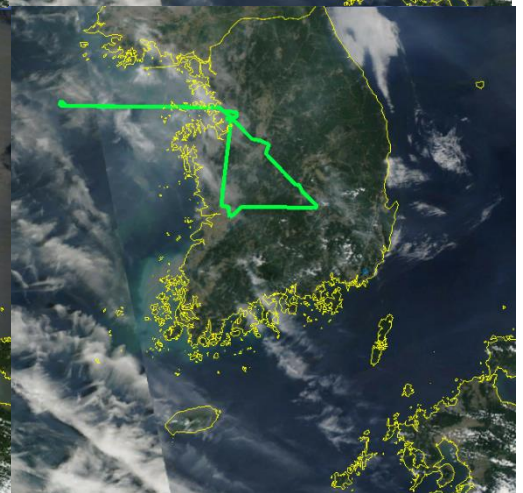
DC-8 Objectives: Conduct sampling walls over the West Sea in the morning and the Seoul-Busan jetway in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: Afternoon flight over the DC-8 sampling twice along a loop covering Seoul-Daegu-Busan-Pohang

Hanseo King Air Objectives: Sample along the Seoul-Jeju jetway and upwind and downwind of sources on the southern coast of the peninsula in the morning and afternoon.

Notes: DC-8 encountered difficulty coming onshore NE of Busan due to undocumented restrictions around nuclear power plants on the SE coast.



20 May (Local) – Local pollution under continued warming

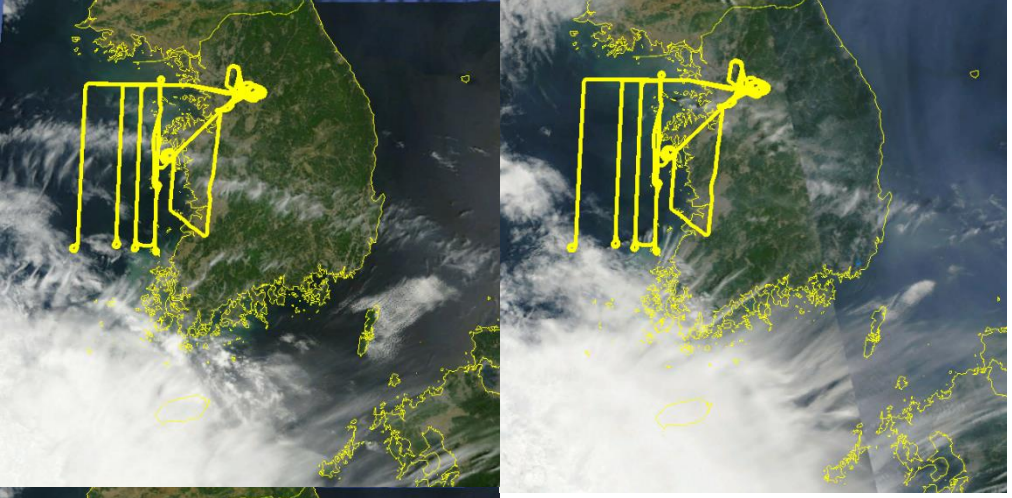
Setting: Minimal outside influence on the Korean peninsula under continued stagnant conditions with weak flow to the west and smoke approaching from the east. Increasing temperatures continue to raise the expectation of increased biogenic emissions.

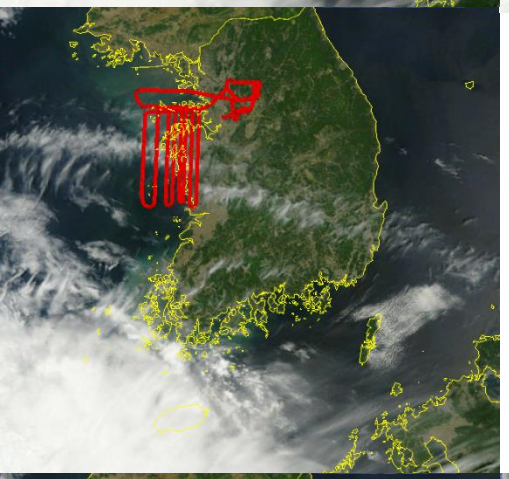
DC-8 Objectives: Conduct sampling walls in the morning and afternoon along the Seoul-Busan jetway. In the morning, extend sampling offshore of Busan to the northeast with the lidar and return at 500 feet. In the afternoon, spiral down over the RV Onnuri SE of Busan. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

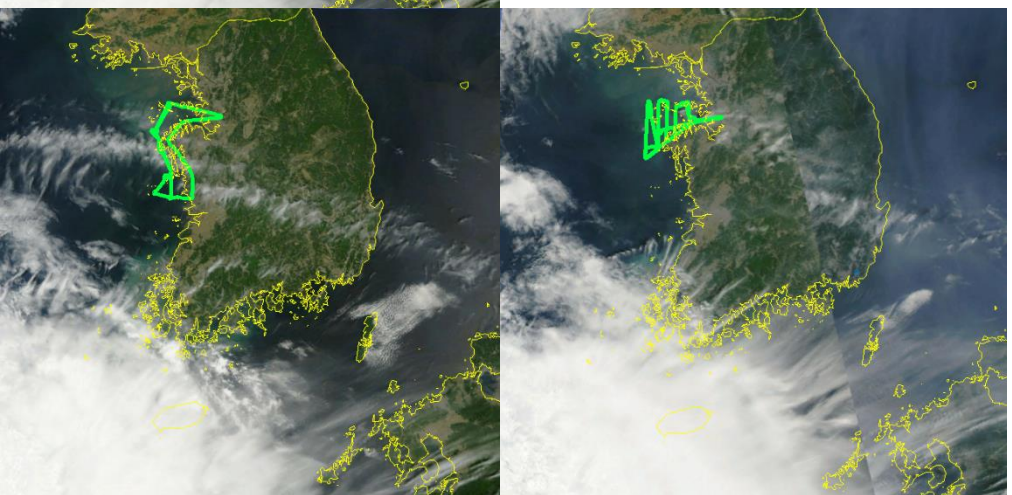
NASA King Air Objectives: Morning sampling over Seoul and then over sources on the southern coast (Gwangju-Jeju-Busan triangle) in concert with the Hanseo King Air. Afternoon sampling over Seoul and then over the Seoul-Busan jetway in concert with the DC-8 in addition to overflight of the RV Onnuri offshore SE of Busan.

Hanseo King Air Objectives: Sample sources on the southern coast in the morning and onshore-offshore gradients in the afternoon.

Notes: Late departure of the RV Onnuri prevented DC-8 overflight. King Air afternoon takeoff was delayed to enable overflight of the ship. DC-8 worked the morning wall bottom up due to the shallow mixed layer, and the afternoon wall top down to get the leg at 1000 feet as late (hot) in the day as possible.







22 May (Local) – Seoul plume and point source transport to West Sea

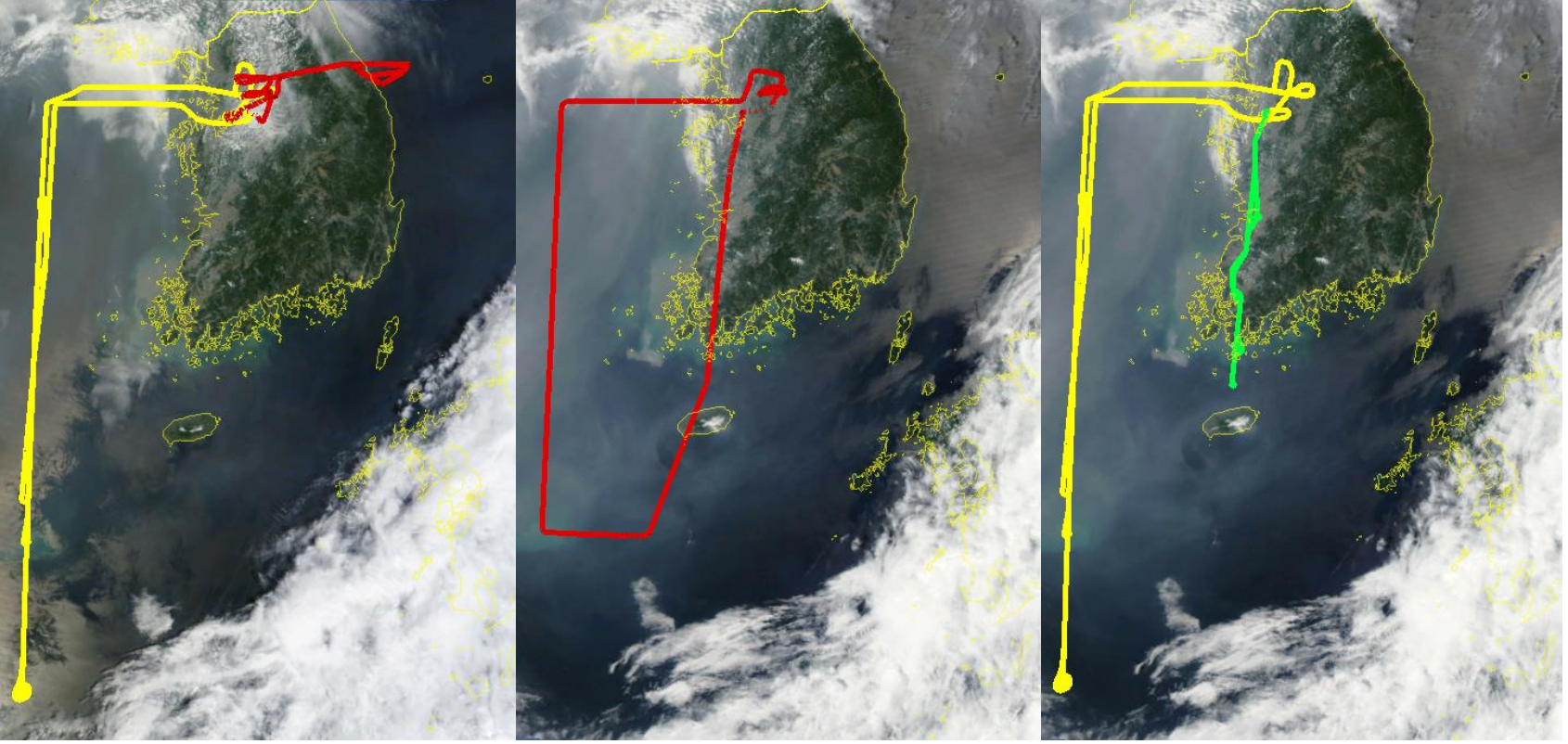
Setting: Easterly flow pushing the Seoul plume and point source emissions over the West Sea on a weekend day when access to restricted airspace is possible.

DC-8 Objectives: Fly over the West Sea to sample the Seoul Plume and point source emissions at several distances. Conduct a TCCON spiral over Anmyeon and sample at low altitude along the Seoul-Jeju jetway. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: Overfly Seoul and map point source emissions and their transport westward in concert with the DC-8.

Hanseo King Air Objectives: Fly upwind and downwind in close proximity to point sources in the morning and follow their westward transport in the afternoon.

Notes: There were no problems in executing these flights. An unanticipated opportunity allowed the DC-8 to overfly the RV Kisang on the sampling leg closest to the coast.



25 May (Local): Chinese emissions and survey of pollution over the West Sea

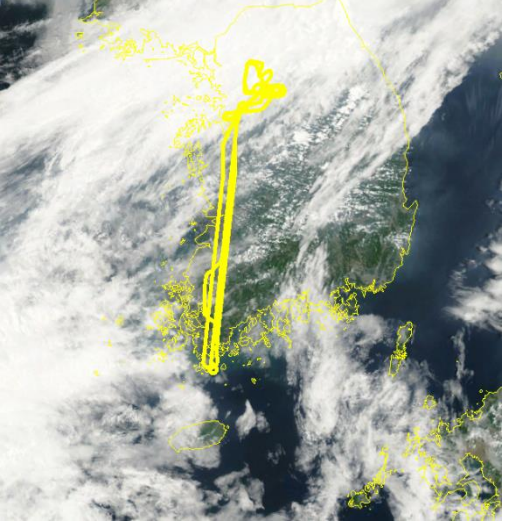
Setting: Models indicated a potentially strong incursion of Chinese pollution to the West Sea (mainly from the Shanghai area), possibly transporting NE across the southernmost parts of the Korean peninsula.

DC-8 Objectives: Conduct an extended sampling wall over the West Sea to sample pollution. Overfly the RV Kisang located along the West Sea route. Also execute the Seoul stereoroute and Taehwa spiral at the beginning and end of the flight.

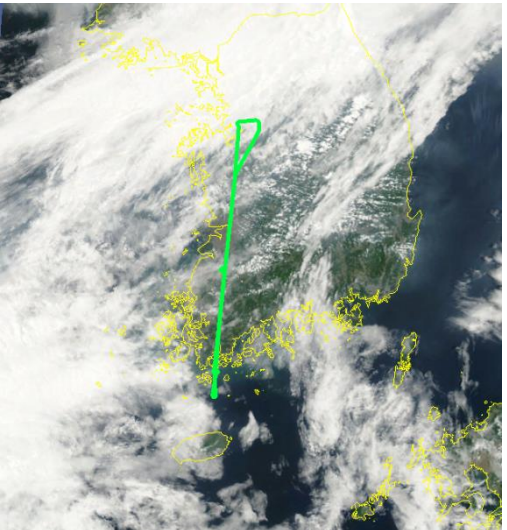
NASA King Air Objectives: Morning sampling with an overflight of Seoul and triangle pattern over the RV Onnuri in the East Sea. Afternoon sampling over Seoul followed by an extended loop over the West Sea to coordinate with the DC-8 and returning along the Seoul-Jeju jetway to coordinate with the Hanseo King Air.

Hanseo King Air Objectives: Sample along the Seoul-Jeju jetway.

Notes: Due to exceptionally interesting pollution over the West Sea, sampling was extended to allow more coverage and the final Seoul stereoroute and Taehwa spiral were sacrificed.



No Flight



26 May (Local): Frontal Crossing

Setting: A frontal passage was expected to be crossing the northern part of the Korean peninsula with an opportunity to sample across the frontal cloud boundary.

DC-8 Objectives: Conduct a sampling wall in the afternoon along the Seoul-Jeju jetway using IFR control to sample across frontal cloud boundaries. Also execute the Seoul stereoroute and Taehwa spiral at the beginning and end of the flight.

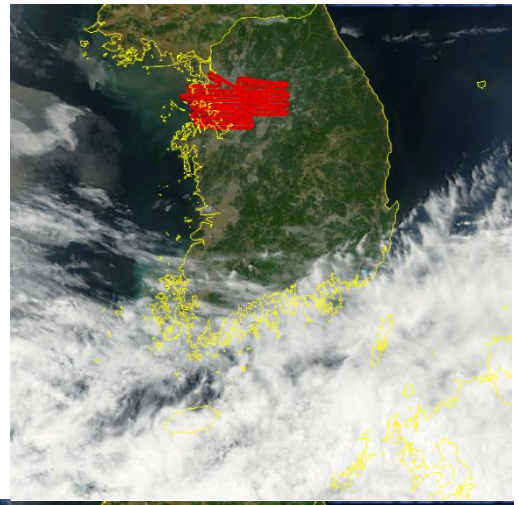
NASA King Air Objectives: No flight

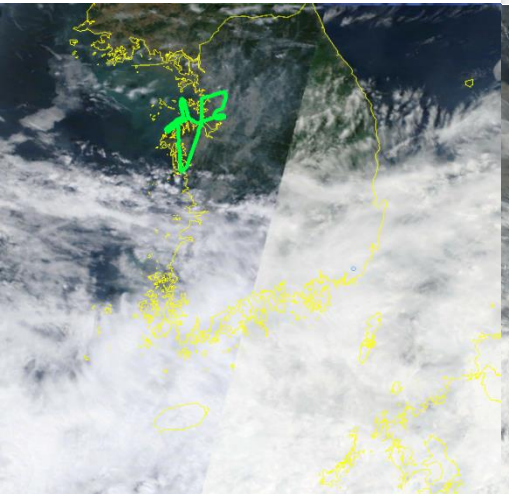
Hanseo King Air Objectives: Sample along the Seoul-Jeju jetway in coordination with the DC-8.

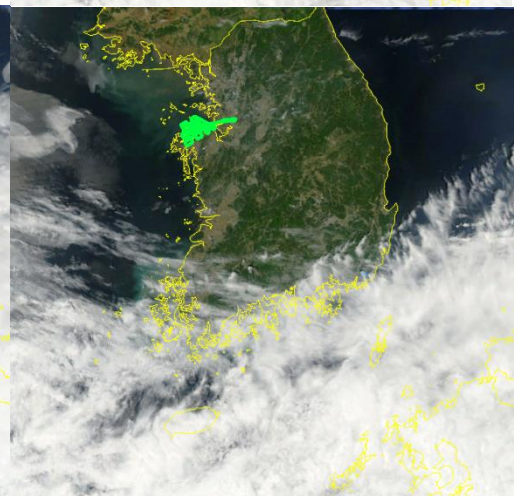
Notes: Initial Taehwa spiral was interrupted. Otherwise, flight sampling was accomplished as planned. However, the front pushed southward more slowly than forecast, so we were not able to cross it. We did repeatedly sample in the leading edge of frontal clouds near Seoul, but were ahead of the front throughout the flight at more southerly locations along the wall.

28 May (Local) – Mapping and Source Characterization

No Flight







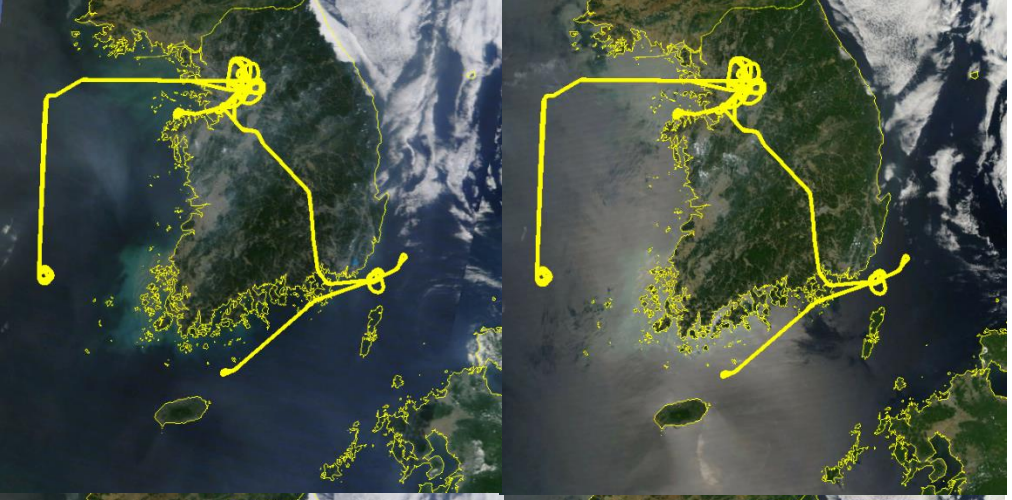
Setting: Clear conditions over the northern part of the Korean peninsula with no notable transboundary influence.

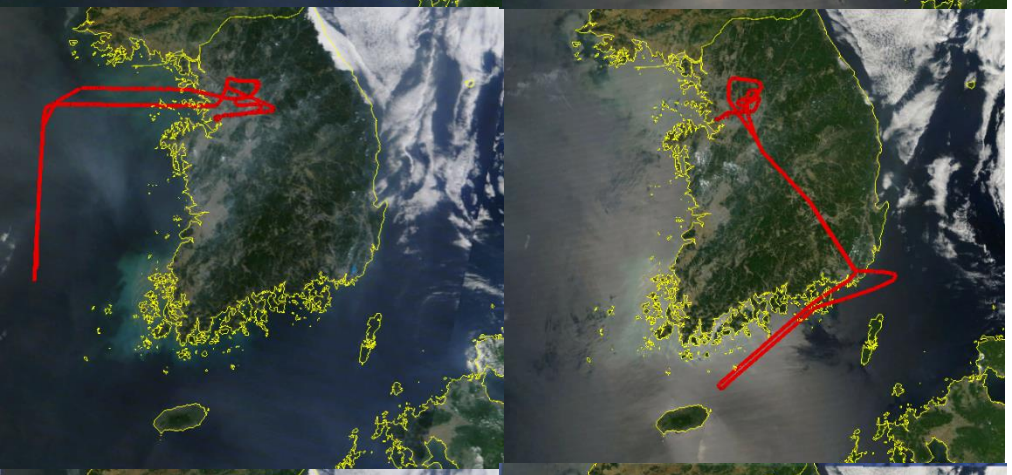
DC-8 Objectives: No flight

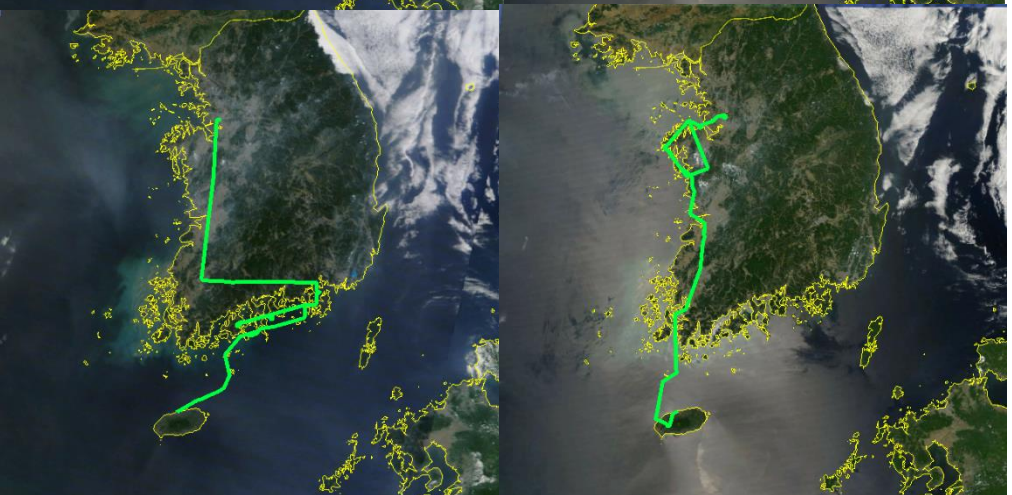
NASA King Air Objectives: Raster sampling to map the Seoul Metropolitan area, taking advantage of clear skies in the north.

Hanseo King Air Objectives: Morning and afternoon sampling of point sources along the northwest coast of Korea.

Notes: Flight sampling accomplished as planned.







30 May (Local) – Bibimbap: A little bit of everything

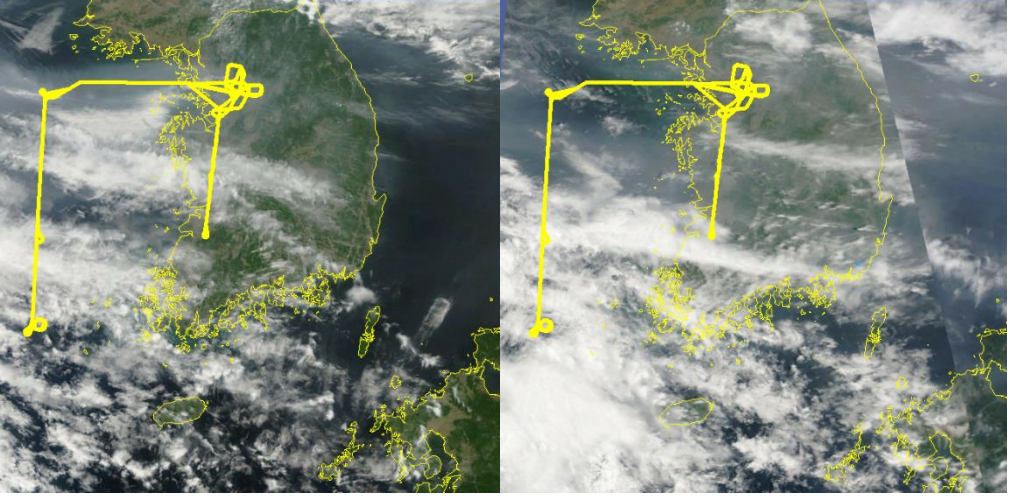
Setting: Under clear conditions, increasing temperatures, and light surface flow to the southeast, opportunities included fresh pollution from China over the West Sea, transport of the Seoul plume to the southeast with the expectation for increased biogenic emissions, and outflow of emissions off the southern coast.

DC-8 Objectives: Conduct sampling in the morning over the West Sea with a spiral over the RV Onnuri. In the afternoon, sample along the Seoul-Busan jetway and over the Korea Strait. Morning sampling included two Seoul stereoroutes separated by overflight of the Daesan chemical facility. Seoul stereoroutes and Taehwa spirals were also conducted at the middle and end of the flight.

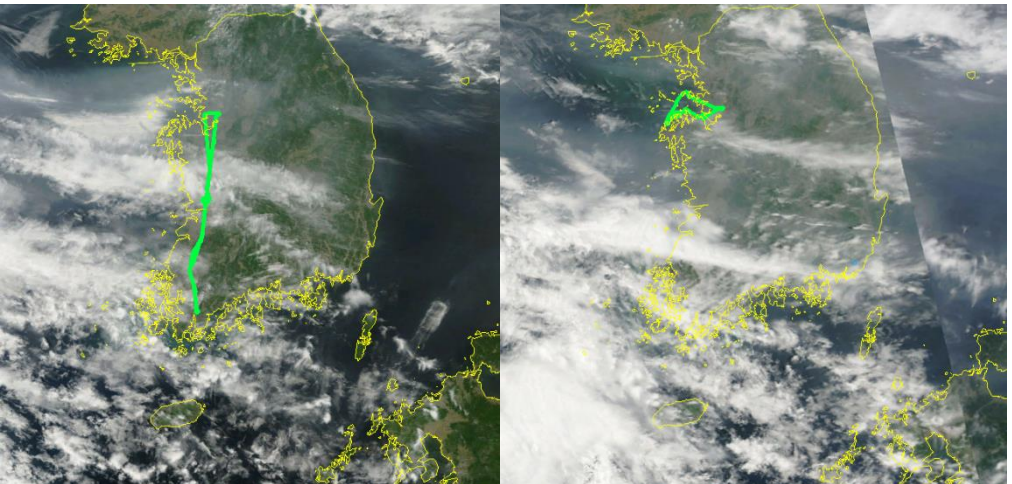
NASA King Air Objectives: Flight to the West Sea in the morning to perform a raster pattern over the RV Onnuri and coordinate with DC-8. Afternoon sampling continued coordination with DC-8 along the Seoul-Busan jetway and Korea Strait. Seoul overflight was included in both sorties.

Hanseo King Air Objectives: Sampling along the Seoul-Jeju jetway during both sorties was augmented by sampling point sources on the southern coast in the morning and on the northwest coast in the afternoon.

Notes: Flight sampling accomplished as planned.



No Flights



31 May (Local) – Direct Inflow from China

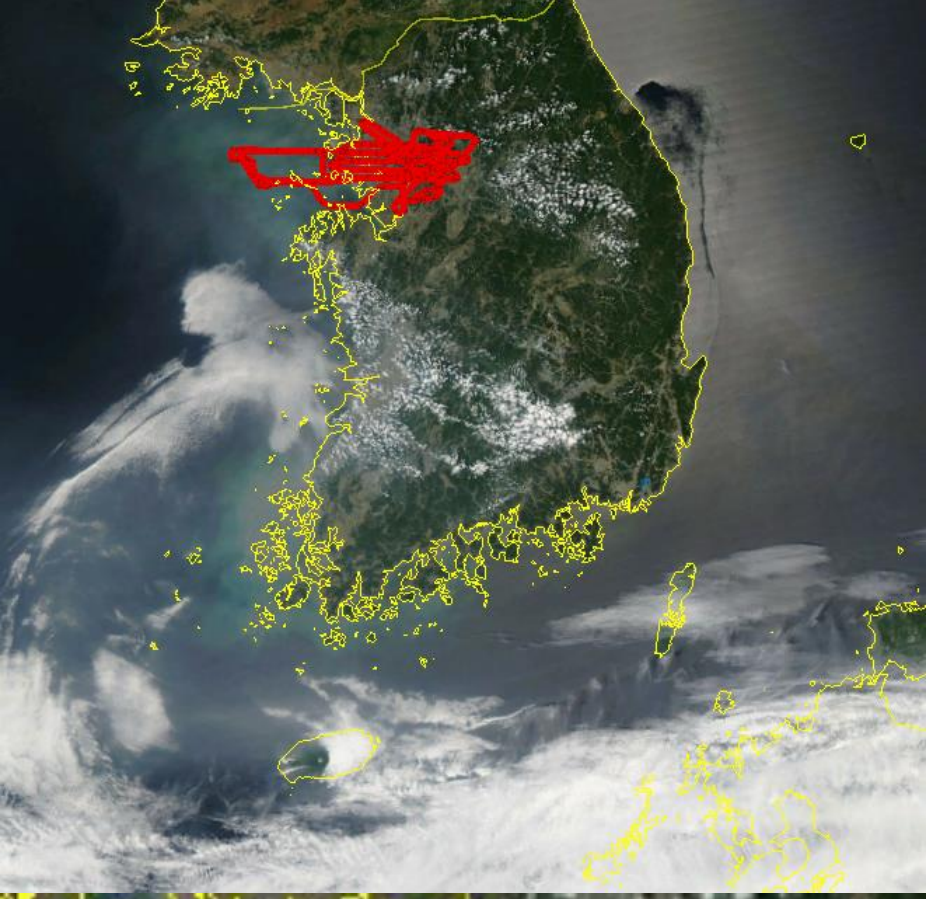
Setting: Direct transport of Chinese emissions to the Korean peninsula was expected for the first time in the campaign. Clouds are expected to influence flight sampling.

DC-8 Objectives: Conduct wall sampling offshore in the morning and along the Seoul-Jeju jetway in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: No flights due to cloudy conditions.

Hanseo King Air Objectives: Sample along the Seoul-Jeju jetway in the morning and focus on point sources on the northwest coast in the afternoon.

Notes: Due to an abundance of vertical structure in pollution over the West Sea, the DC-8 returned west over the water after the second Taehwa spiral to sample by continuously ascending and descending along the western route. This led to abbreviated sampling only over the northern end of the Seoul-Jeju jetway. This adjustment did not sacrifice the Seoul stereoroutes or Taehwa spirals.



1 June (Local) – KORUS-OC overflight and Seoul Raster

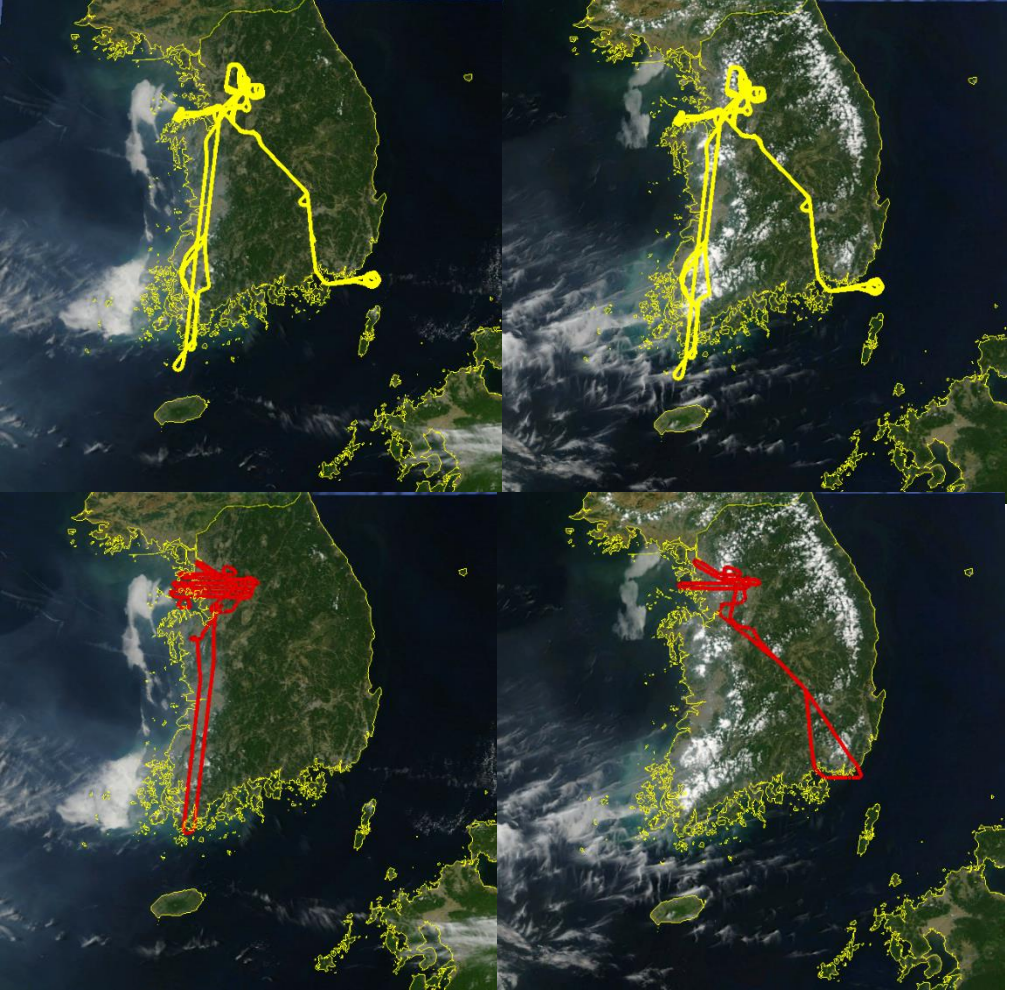
Setting: Clear conditions under the expectation of moderately polluted conditions dominated by local influence.

DC-8 Objectives: No flight (Hard Down Day)

NASA King Air Objectives: Overfly the RV Onnuri and conduct raster sampling over Seoul.

Hanseo King Air Objectives: No flight

Notes: The flight was accomplished as planned with three passes over the RV Onnuri that were accomplished 90 minutes apart.



No Flights

2 June (Local): Local influence

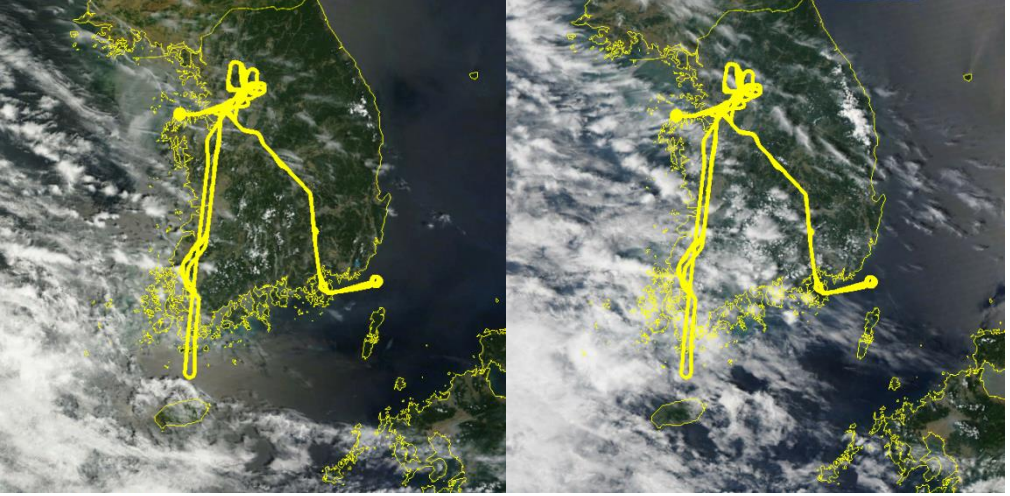
Setting: Stagnant conditions with some scattered cloudiness.

DC-8 Objectives: Conduct wall sampling along the Seoul-Jeju jetway in the morning and the Seoul-Busan jetway in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight. Overflight of the Daesan chemical facility was included at the end of the morning sampling and before the second Seoul stereoroute.

NASA King Air Objectives: Conduct sampling in concert with the DC-8 along the Seoul-Jeju jetway in the morning and the Seoul-Busan jetway on the afternoon, including direct overflight of the Busan Pandora. Both sorties also include a Seoul raster.

Hanseo King Air Objectives: No flights (maintenance)

Notes: Two hour refueling delay for second King Air sortie. DC-8 flight below 10,000 feet was restricted over the Seoul-Busan jetway in the early afternoon (until 1340 local) due to student hearing tests. The final DC-8 overflight of Taehwa was pushed high by ATC (likely related to paratrooper operations).



3 June (Local): Local Influence with building pollution

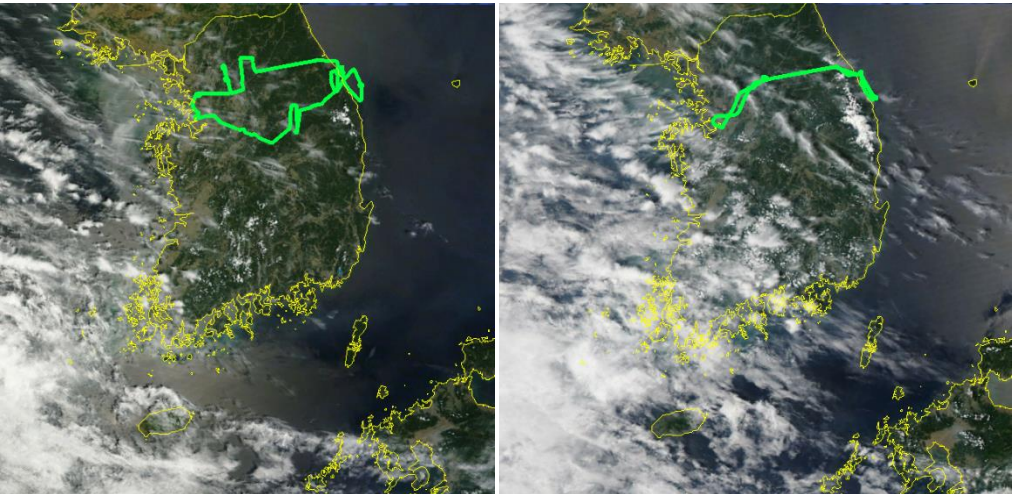
Setting: Stagnant conditions with increasing clouds and model prediction of increased ozone compared to the previous day.

DC-8 Objectives: Conduct wall sampling along the Seoul-Jeju jetway in the morning and the Seoul-Busan jetway in the afternoon. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight. Overflight of the Daesan chemical facility was included at the end of the morning sampling and before the second Seoul stereoroute.

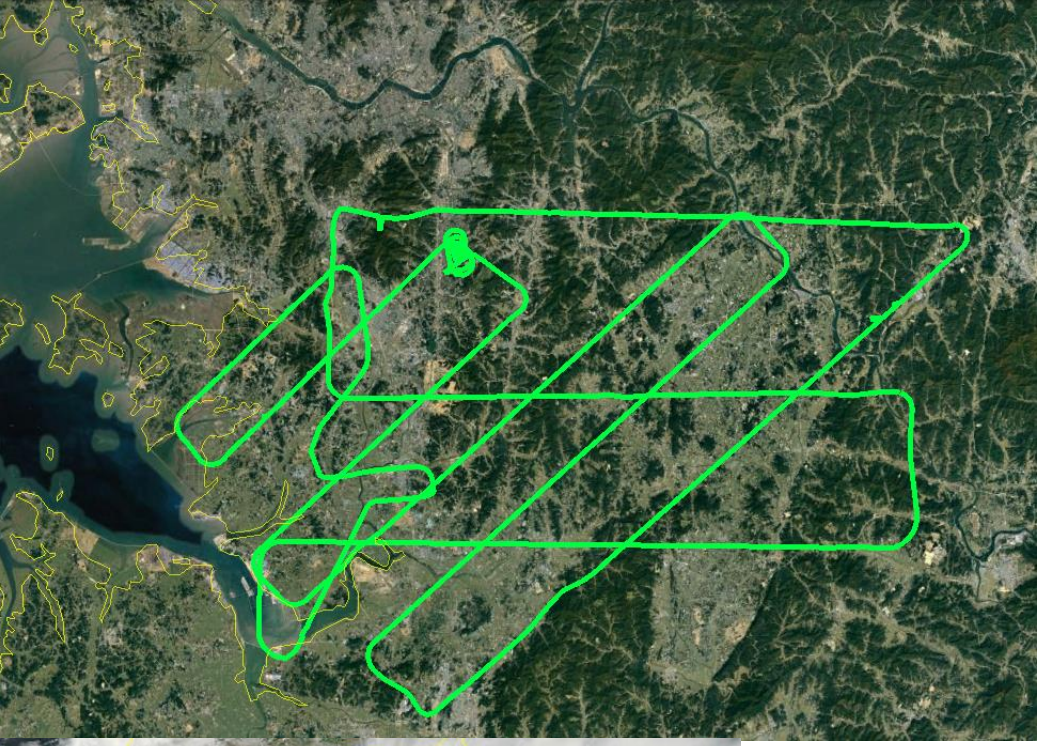
No Flights

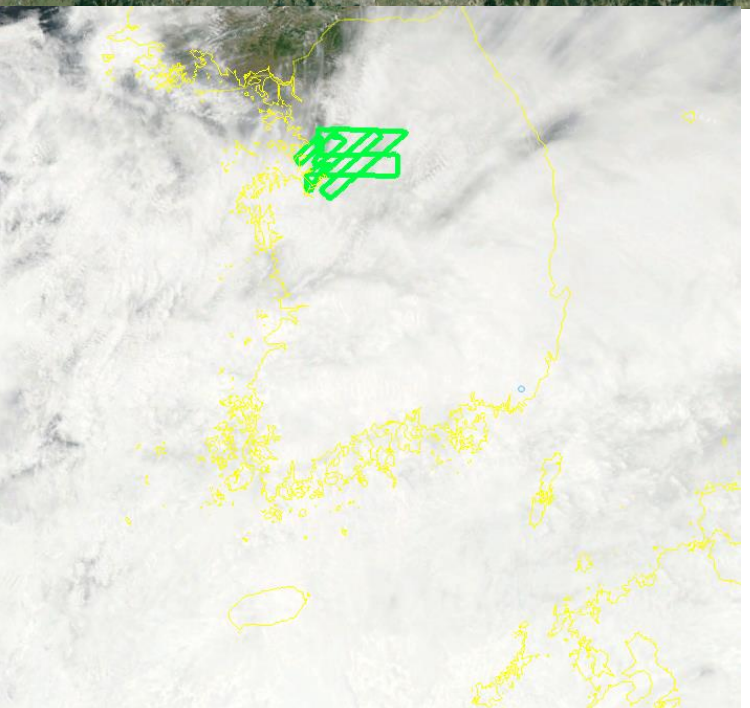
NASA King Air Objectives: No flights (maintenance)

Hanseo King Air Objectives: Sample point sources and pollution along the Seoul-East Sea jetway.



Notes: Flights were executed as planned. The DC-8 track heading offshore near Busan was shifted slightly to overfly shipbuilding facilities.





4 June (Local): Holiday Traffic Emissions Survey

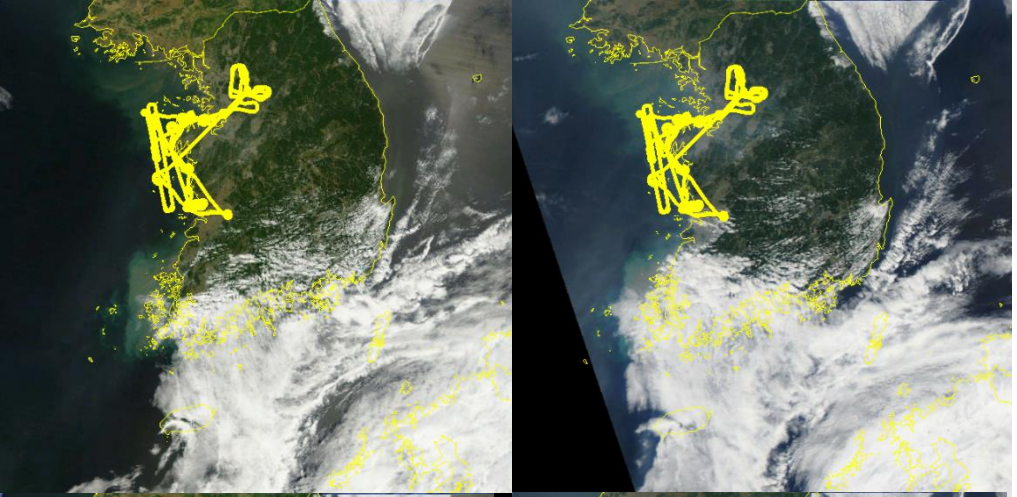
Setting: While cloudy conditions were not conducive to remote sensing, extensive holiday traffic exiting Seoul was expected for the Memorial Day weekend.

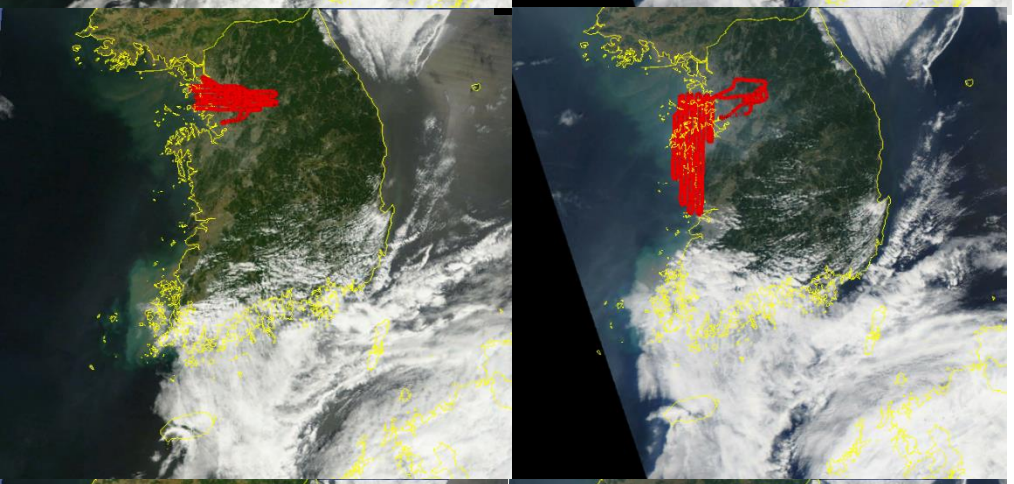
DC-8 Objectives: No flights

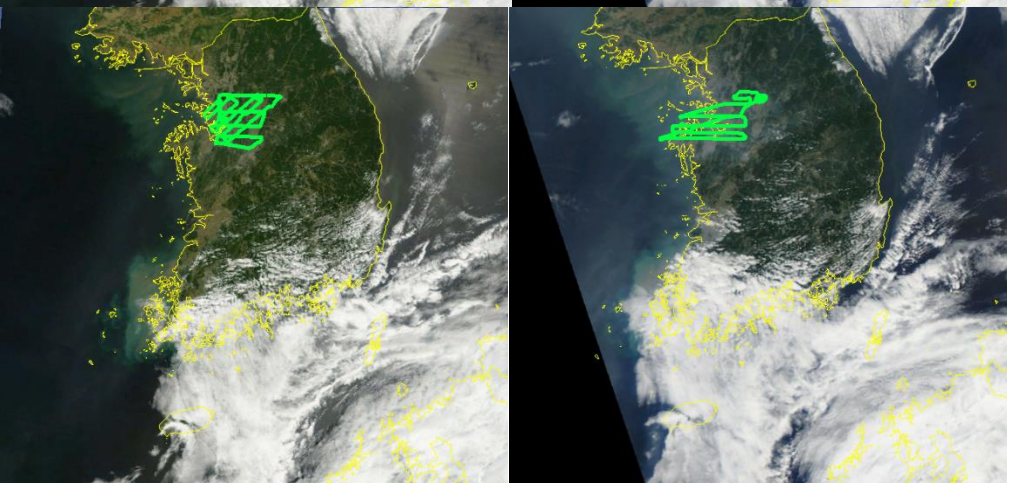
NASA King Air Objectives: No flights

Hanseo King Air Objectives: Sample along major traffic corridors to assess emissions.

Notes: The flight was executed as planned.







5 June (Local): Point Source Survey

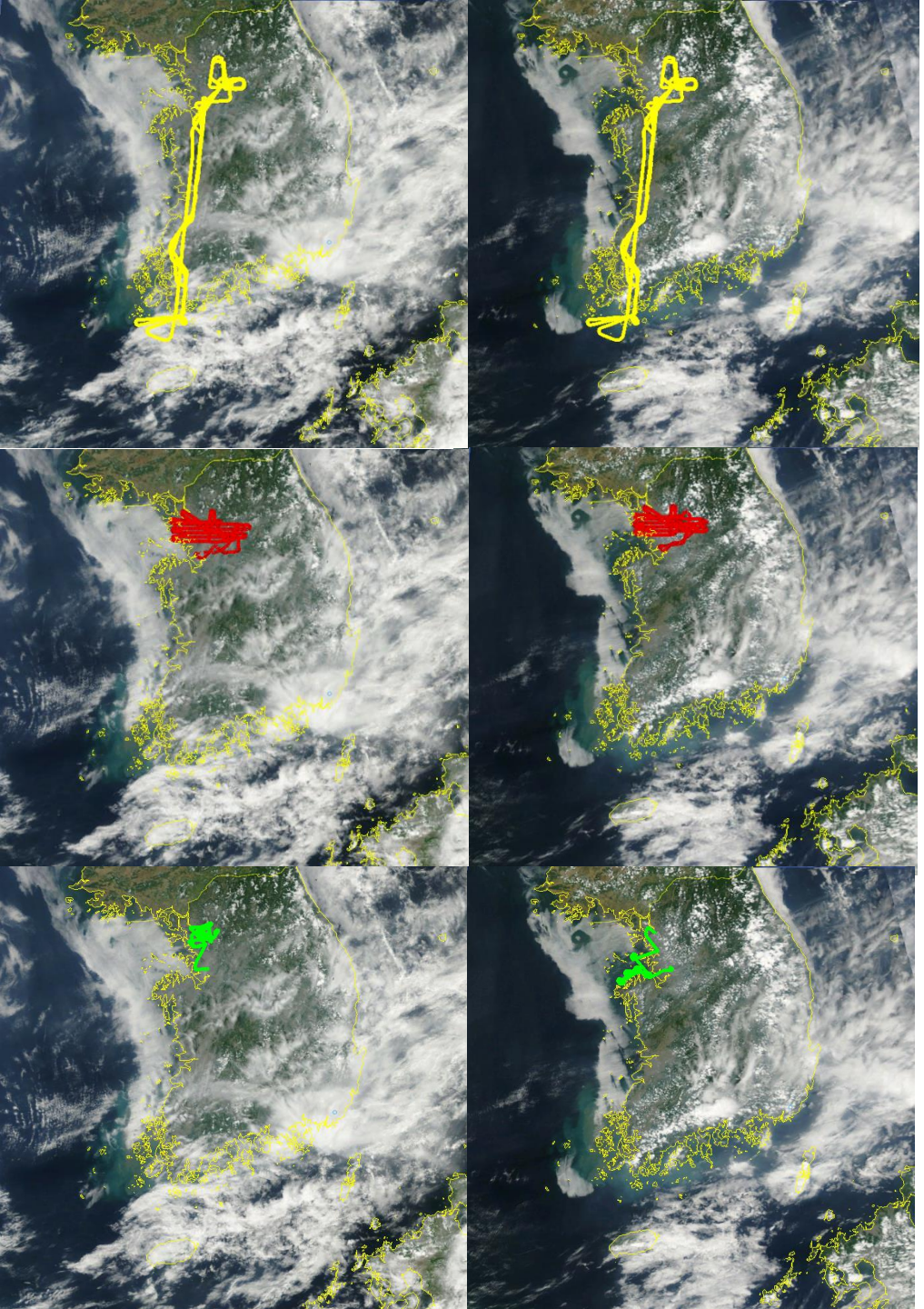
Setting: Expectation of clear skies in the north and slow transport of point source emissions to the south.

DC-8 Objectives: Targeted sampling of point sources with AM and PM sampling of industrial sites and PM only sampling of power plants. Also execute the four consecutive Seoul stereoroutes in the morning followed by the Taehwa spiral at the beginning of the flight. End the flight with a single Seoul stereoroute and Taehwa spiral.

NASA King Air Objectives: Seoul rastering twice in the morning and point source rastering in the afternoon.

Hanseo King Air Objectives: Point source sampling in coordination with the DC-8 and NASA King Air.

Notes: Other than some adjustments to offshore transects by the DC-8 to capture point source outflow, the flights were accomplished as planned.



9 June (Local): Peninsula Evolution

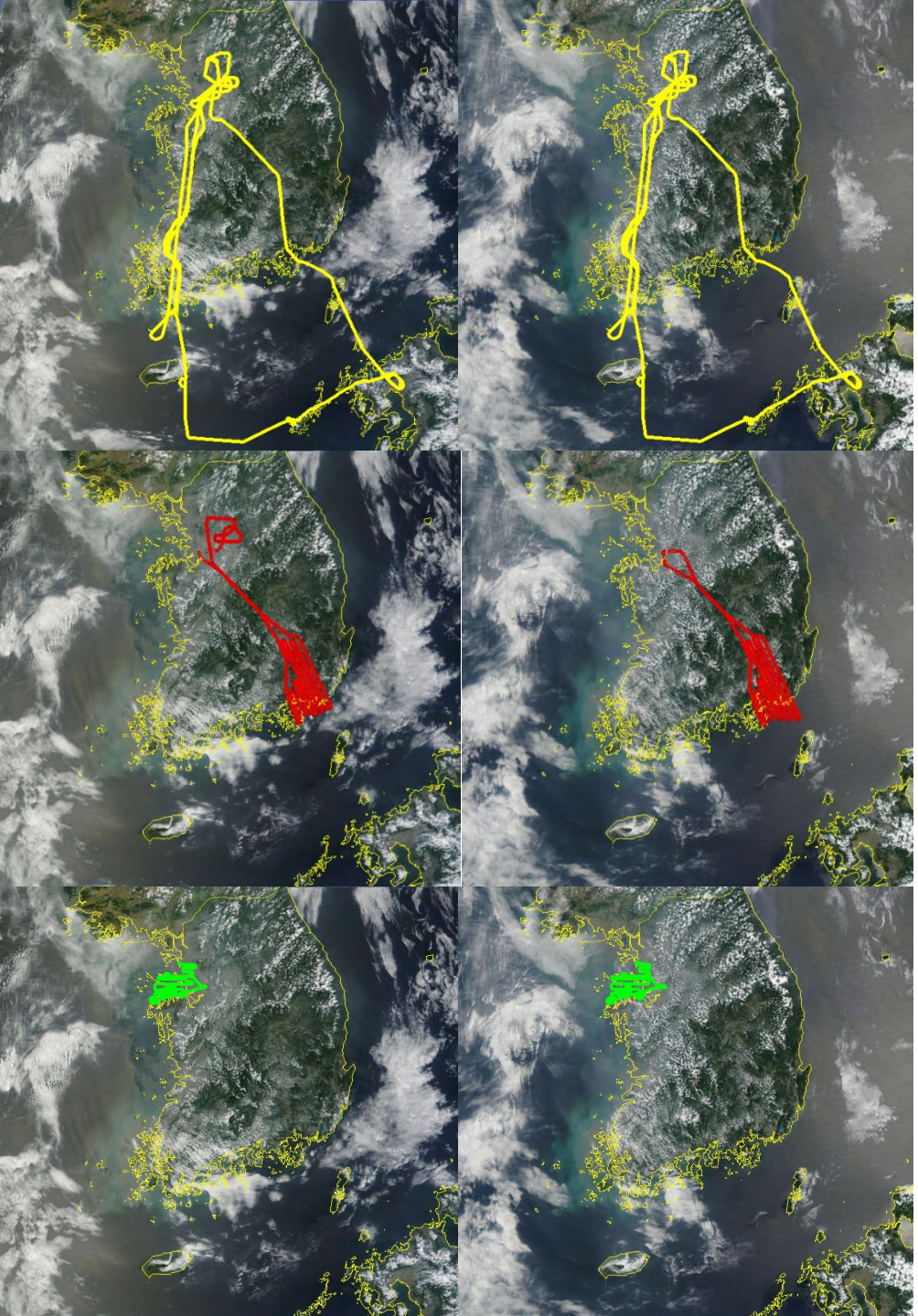
Setting: Models predicted a period of increasing ozone with point source emissions being slowly transported east and south along the western half of the peninsula with light winds and moderate temperatures.

DC-8 Objectives: Conduct a sampling wall in the morning and afternoon along the Seoul-Jeju jetway. Also execute the Seoul stereoroute and Taehwa spiral at the beginning, middle, and end of the flight.

NASA King Air Objectives: Execute a total of four raster patterns over Seoul, two in the morning and two in the afternoon.

Hanseo King Air Objectives: Targeted sampling in the Seoul area reaching north of the Han river in the morning and point source sampling in the afternoon.

Notes: Flights were completed as planned.



10 June (Local) : Peninsula evolution and Japanese overflights

Setting: Models predicted continued increases in ozone for the western half of the peninsula with light winds and increasing temperatures. Favorable cloud conditions for sampling over Japanese sites and possible Chinese emissions being transported south of the Korean peninsula.

DC-8 Objectives: Fly south over the Seoul-Busan jetway to enter Japanese airspace and conduct a spiral over the Saga TCCON site and overflight of the ground site at Fukue. Return to conduct wall sampling over the Seoul-Jeju jetway. Also execute the Seoul stereoroute and Taehwa spiral at the beginning and end of the flight.

NASA King Air Objectives: Execute raster sampling over Busan in the morning and afternoon.

Hanseo King Air Objectives: Point source sampling repeated in the morning and afternoon.

Notes: Airspace coordination in Japan was difficult and the TCCON spiral was limited to the lower atmosphere (21,000 feet), but the overflight of Fukue was very successful. Flights were otherwise completed as planned.