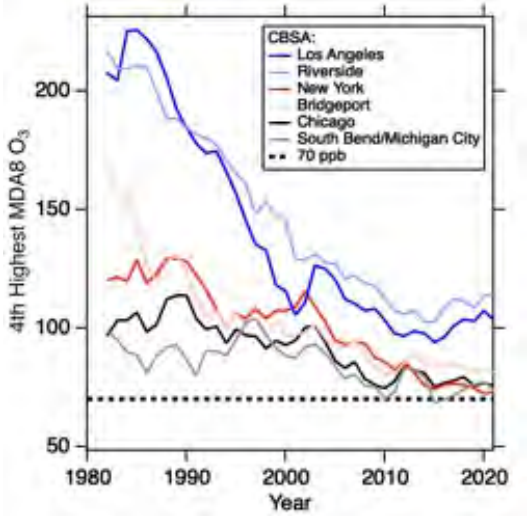
AEROMMA:

Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas

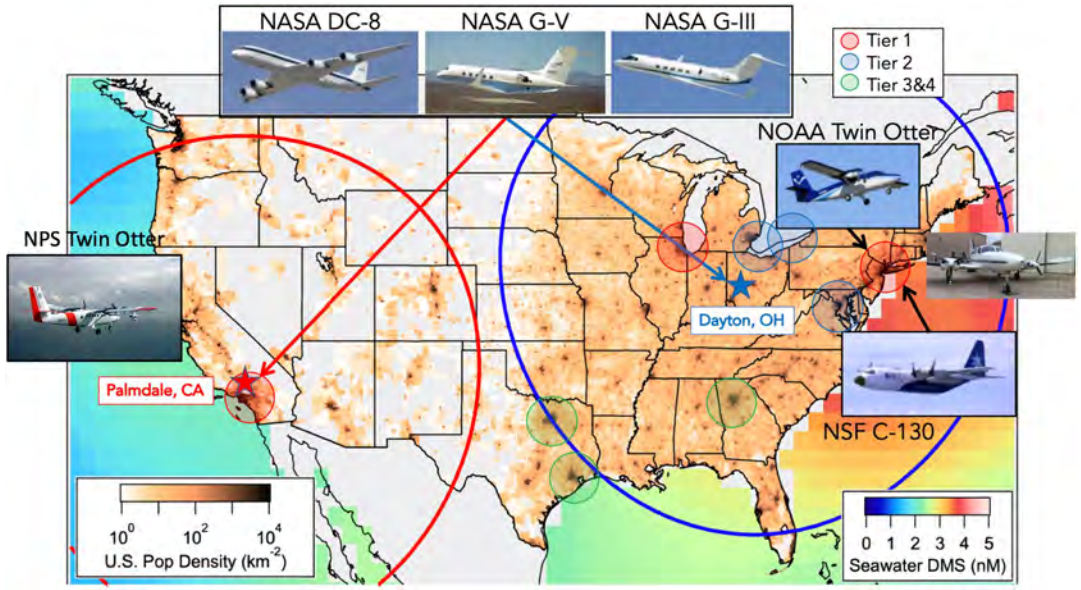
https://csl.noaa.gov/projects/aeromma/

Motivation: Generally ozone has been declining since the 1980s in major US cities, but over the last decade ozone has been stabilizing above the US EPA standard



Goal: Better understand current urban emissions and chemical formation of major air pollutants such as ozone and aerosols to determine why this stabilizing is occurring using both aircraft and geostationary satellites

AEROMMA is part of a large effort across many platforms from NASA, NOAA, NSF, and the university community to study urban air pollution in the summer of 2023



Target Flight Plans for AEROMMA – Urban: Overview Version 5.4

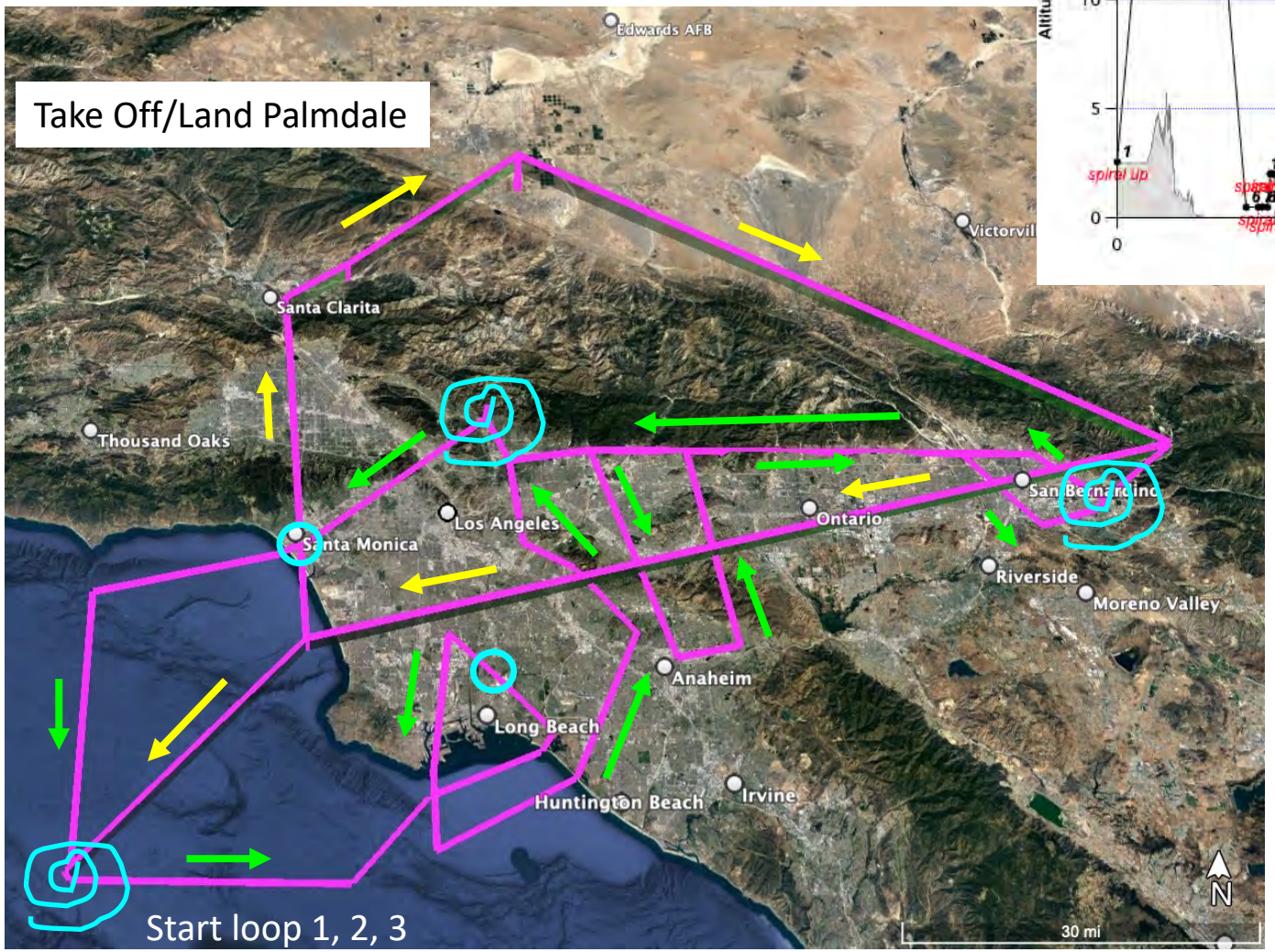
Becky Schwantes and Carsten Warneke
With contributions from the entire AEROMMA/CUPiDs/STAQS/GOTHAAM team

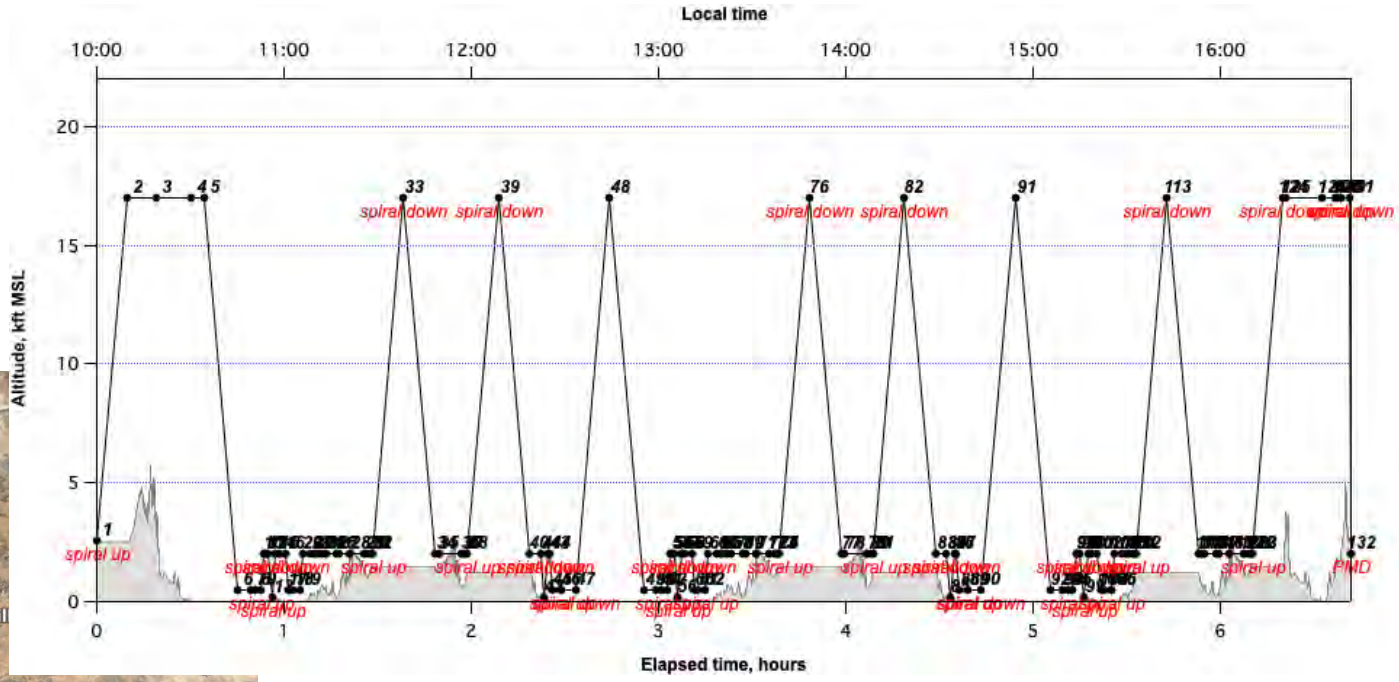
110 flight hours for AEROMMA urban
+ **20 flight hours** for SARP, which is part of AEROMMA science
+ **40 flight hours** for AEROMMA Marine
170 total flight hours

City	# of flights / city	# of ~10 km profiles / flight	# of 5.2 km profiles / flight	Repeat Patterns / flight	Dates
Los Angeles (Tier 1)	3 + SARP (4)	0	9	2.5	June 26 – 28, Aug 20 - 27
New York (Tier 1)	4	2	6	2	July 26 – Aug 16
Chicago (Tier 1)	4	2	4	2	Aug 1 – Aug 16
Toronto (Tier 2)	2	2	4	2	July 26 – Aug 16
Transit	2	2			

Los Angeles: Target Flight Pattern

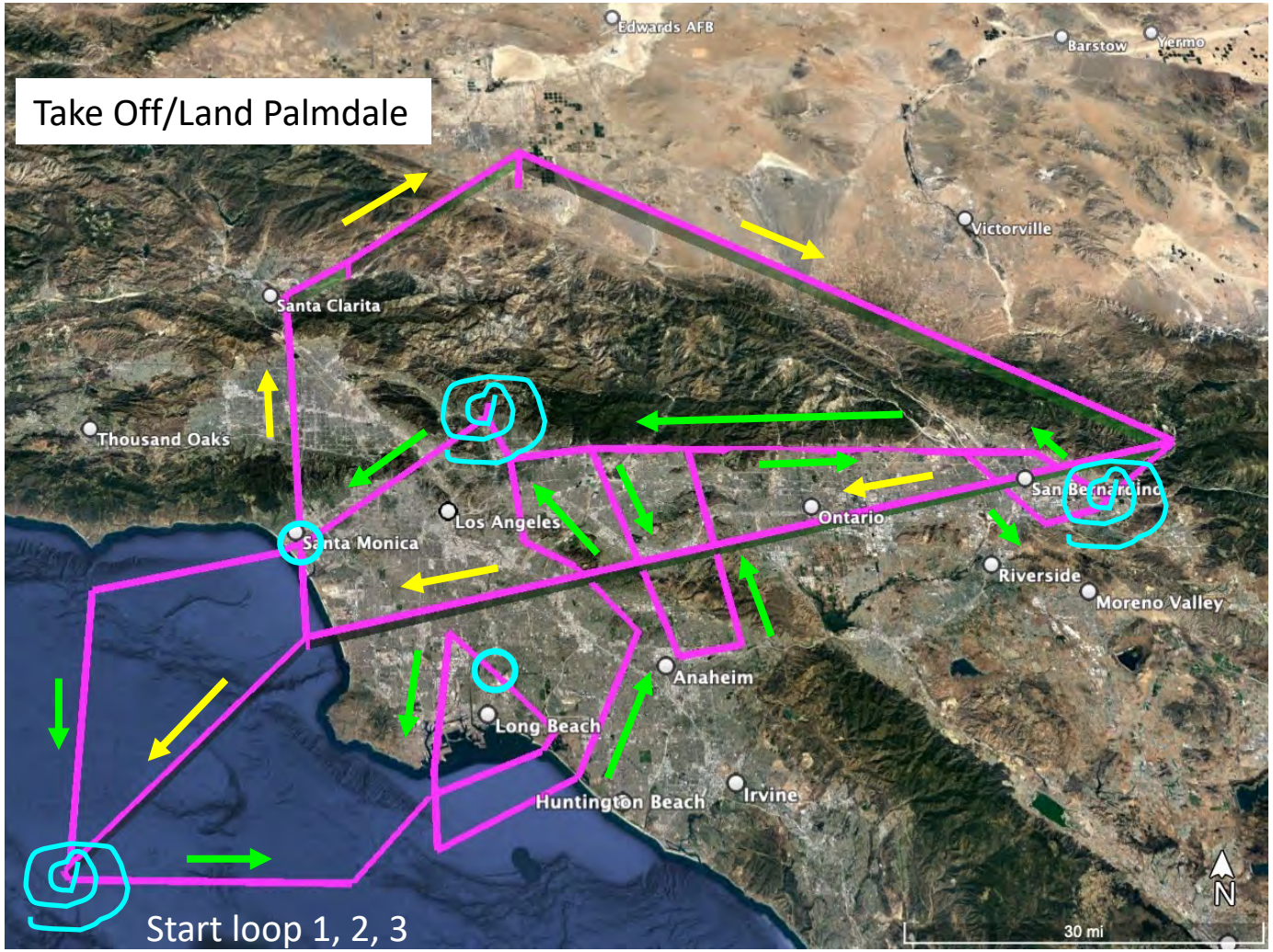
- Total flight time ~ 7-8 hours.
- We may shrink the last loop in flight to fit within the desired total time





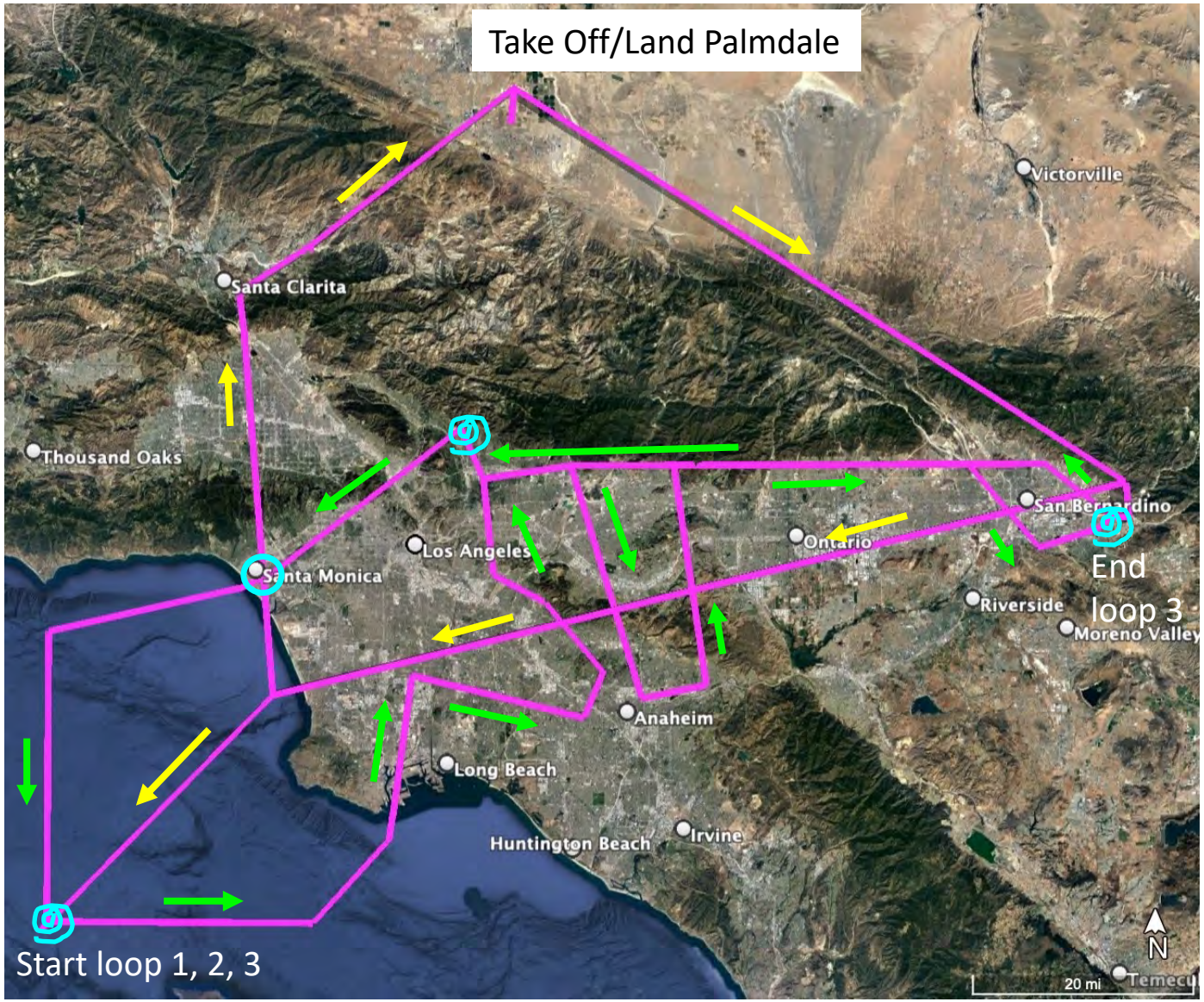
- At start and end of the flight, we fly at 17,000 ft over LA for S-HIS aligned with the G3 and G5 flight legs
- Repeat the green arrow loop ~2.5 times each flight to get diurnal information
- Three spirals from 2,000 ft AGL to 17,000 ft MSL – off coast, Pasadena - JPL (AERONET/TCCON), Redlands
- Two missed approaches – Santa Monica and Long Beach airports
- We fly over Whittier college with a Pandora (33.978, -118.03)
- Rest of the flight within the boundary layer as low as possible (~2,000 AGL land, 500 ft water)

Los Angeles: Target Goals



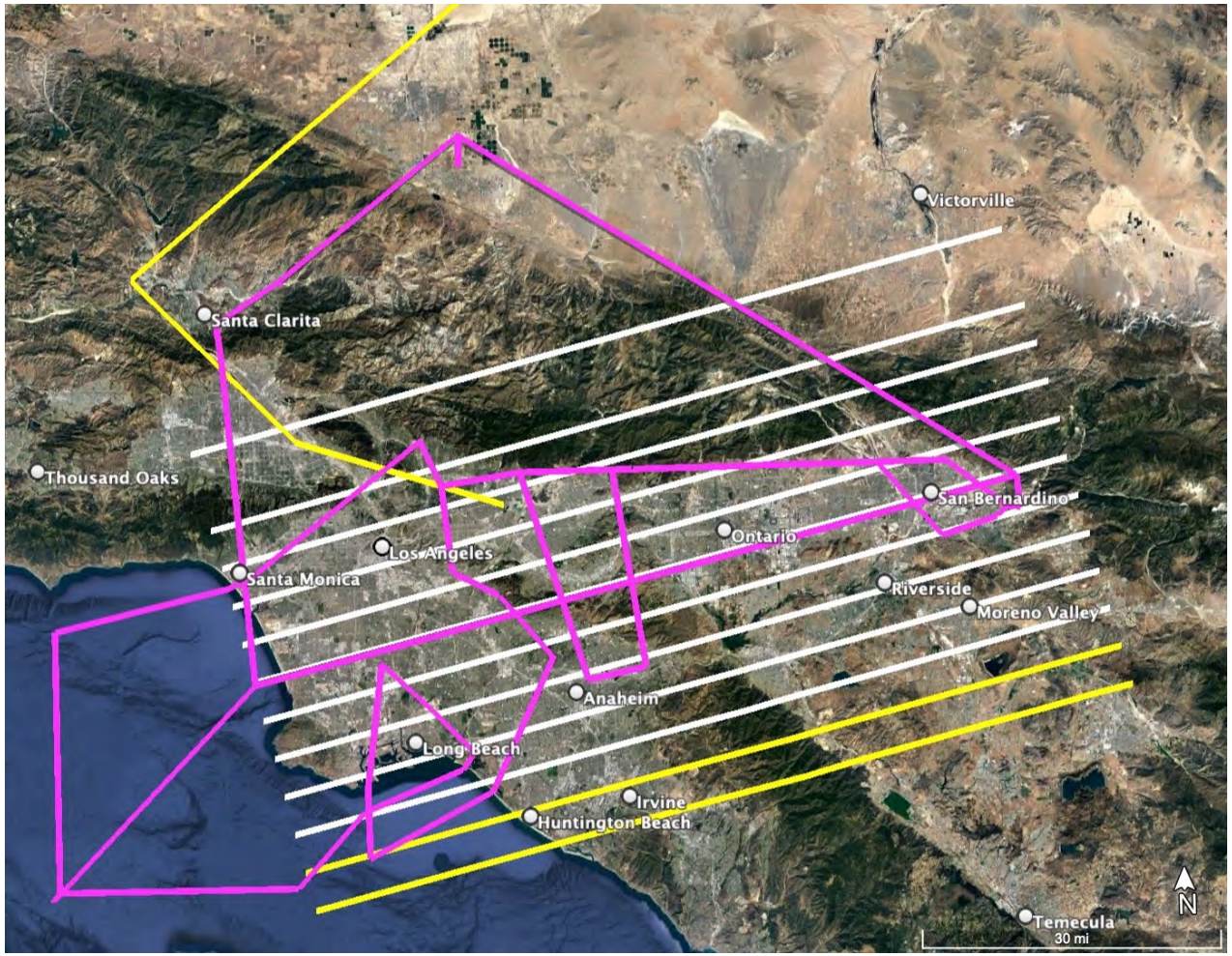
- Repeat the magenta flight track for 3 days
  - Weekday take off at 11 am (preferably close to weekend)
  - Weekend take off at 11 am
  - Weekday take off shifted later in the day (1 pm to 3 pm)
    - Possible low approaches after sunset at a couple airports before RTB
- Priorities for choosing flight days
  - 1) Cloud free
  - 2) AQI Orange/Red
  - 3) Friday/Saturday or Monday/Sunday, so get a clear weekend/weekday contrast under similar meteorological conditions
- The repetition of the magenta flight track provides:
  - daily variability
  - diurnal variability
  - weekend/weekday impact
- The SARP flights (same payload as AEROMMA)
  - Greater coverage and more missed approaches around LA
  - Central Valley
  - Salton Sea

Los Angeles: Target Flight Pattern without Long Beach Airport missed approach



- Optionally skip the missed approach at Long Beach Airport if the boundary layer height is high enough as determined by prior loop or G3/G5 information
- Skipping the Long Beach Airport missed approach
  - Allows us to fly low right over the industrial region
  - Saves us flight time
- This will be decided in flight for each loop
- We will always prioritize the missed approach at Santa Monica airport

Target Logistics: The DC8, G3, & G5 will prioritize flying on the same days

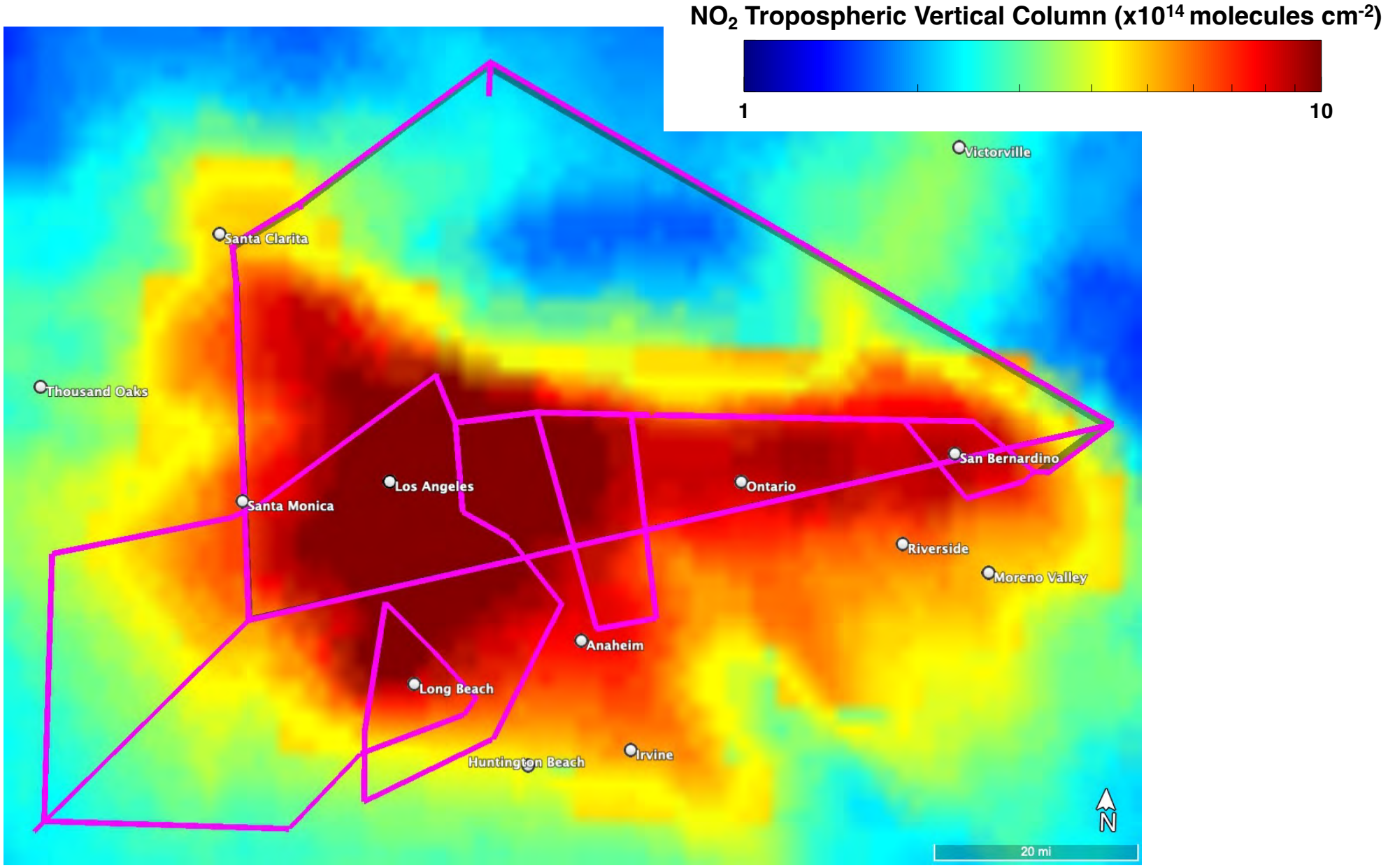


- Generally the horizontal extent will overlap between all 3 platforms.
- The DC8 will fly in the boundary layer with spirals up to 17 kft (5.2 km, FL180). The G3 (FL360) and G5 (FL280) will fly higher altitude raster patterns.
- The G3 and G5 will take off earlier in the day (~8 am) than the DC8 to prioritize having sunlight for their instruments. The DC8 will take off later (~11 am or ~1pm) to ensure that the boundary layer has fully developed. Thus, temporally there will be overlap mostly late morning to late afternoon between the different platforms.

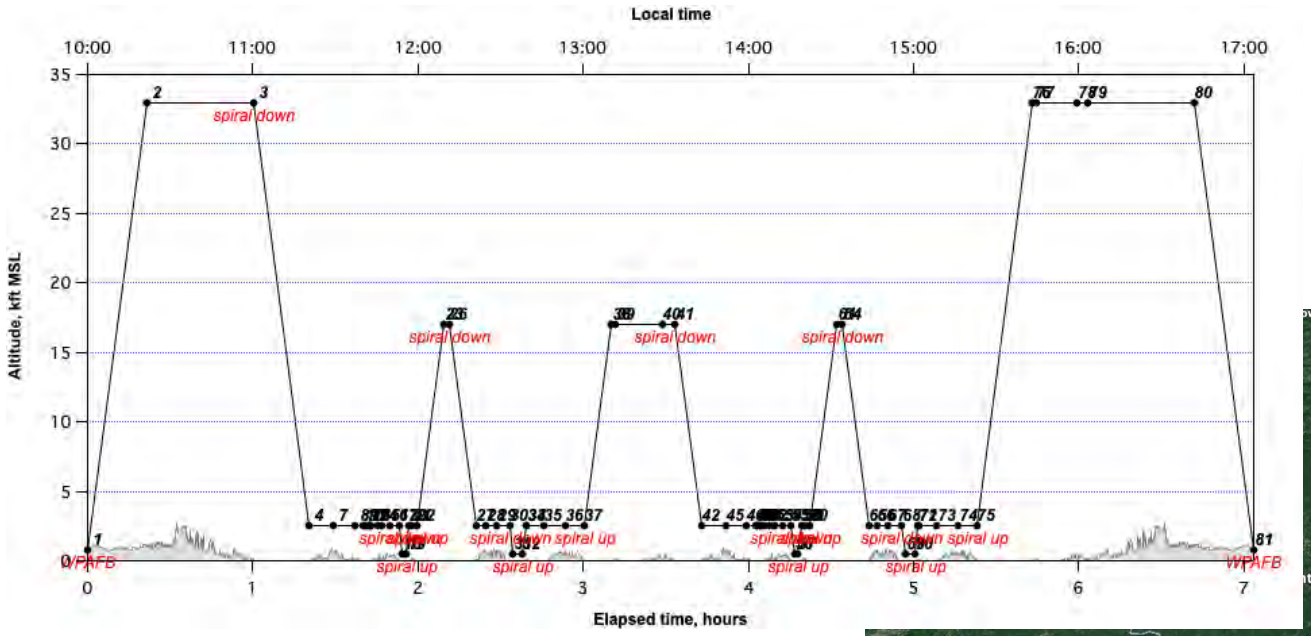
DC8 = magenta, G3 = yellow, G5 = white

Los Angeles: Overlap with TROPOMI

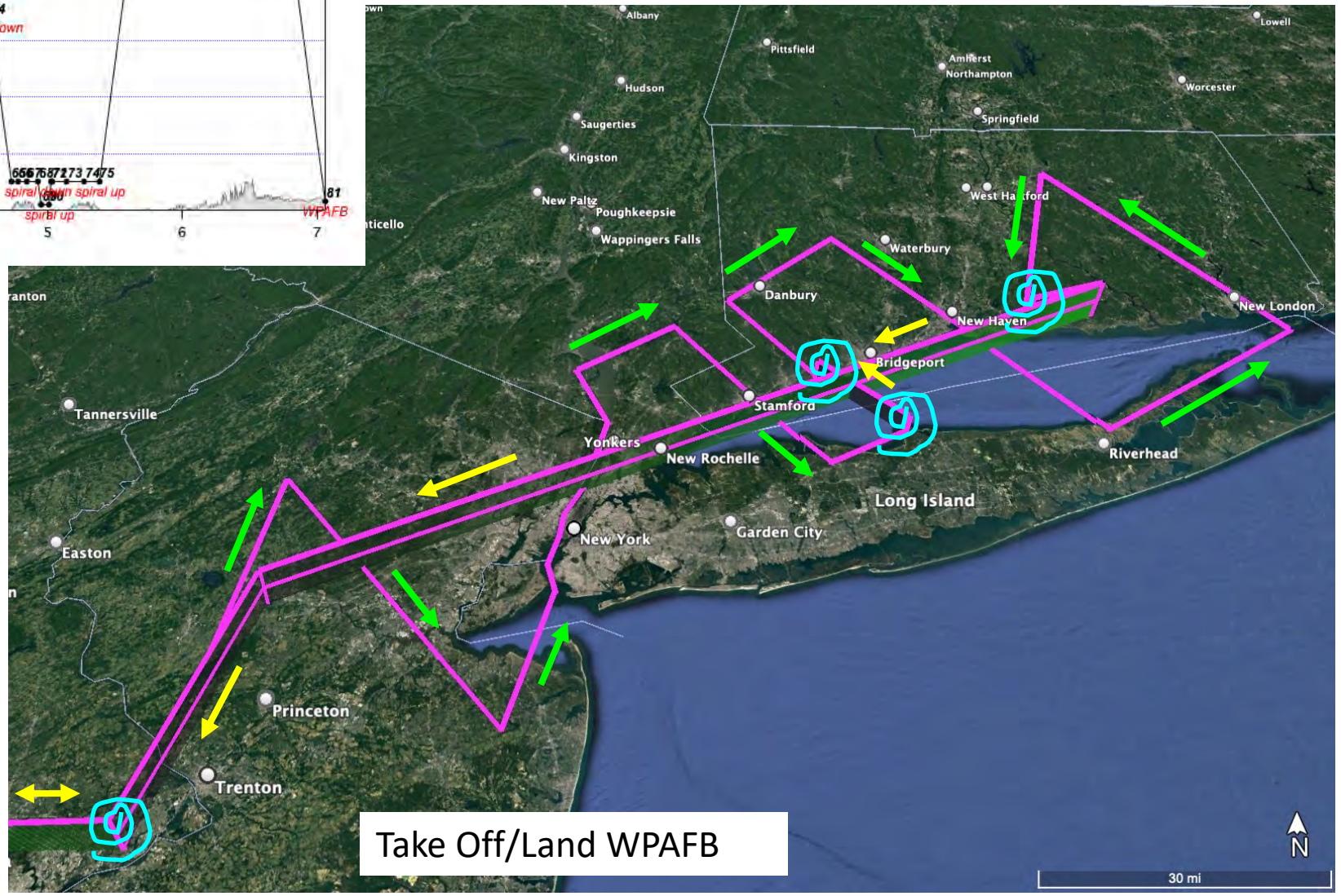
- Annual average of TROPOMI NO_2 from April 2018-March 2019 (logscale) with overlaid DC8 flight plans on top



New York City: Target Flight Pattern 1 wind from the Southwest (primary route)

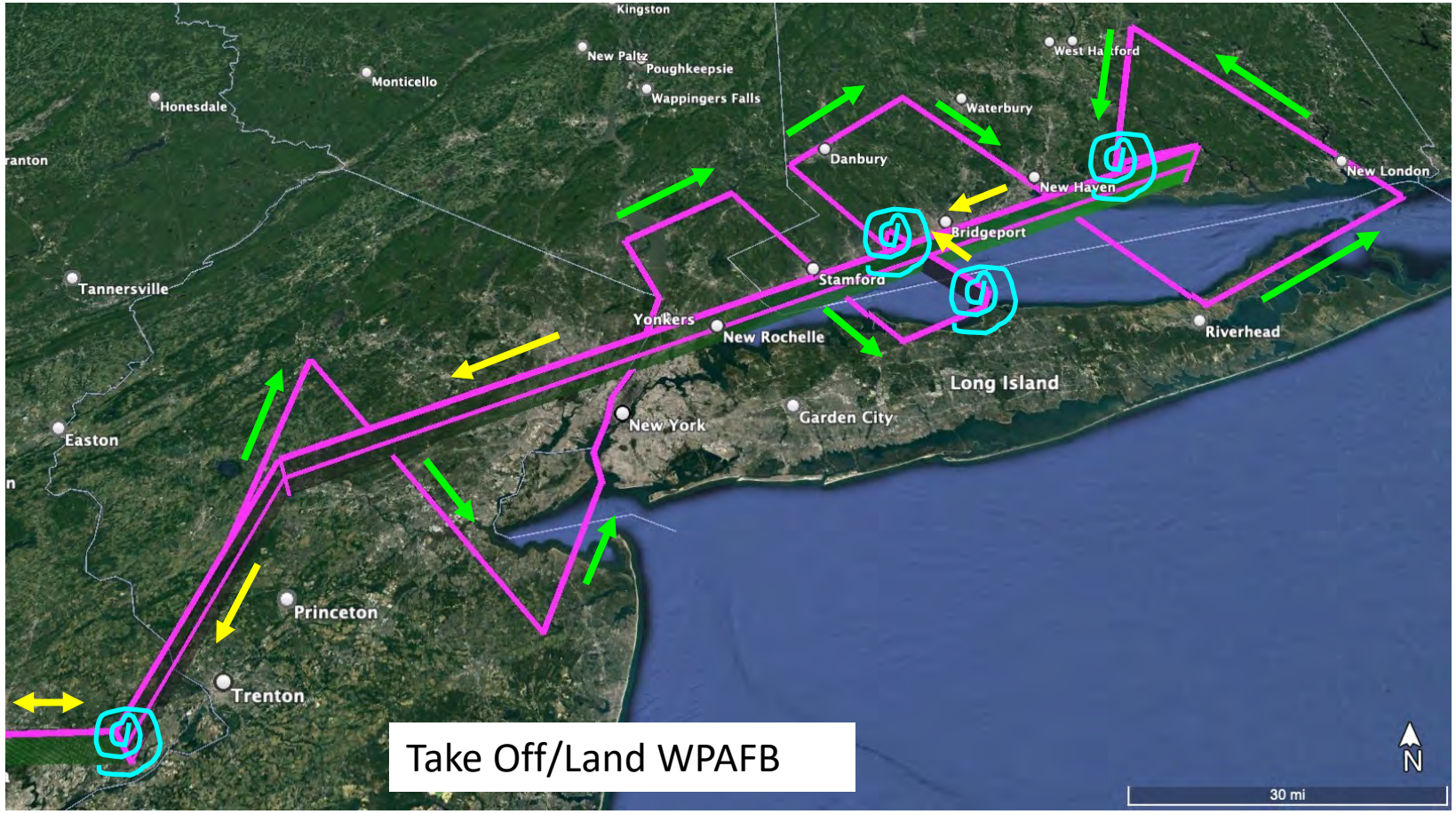


- Total flight time ~ 8 hrs
- Repeat flight plan 2 times each flight to get diurnal information
- Four spirals from 2,500 ft AGL up to 17,000 ft MSL – Bristol (Pandora), Flax Pond (Pandora,TOLNET), Westport (Pandora,TOLNET), Yale Costal Site (TOLNET)
- Rest of the flight in boundary layer as low as possible (~2,500 ft AGL land, dip to 500 ft over Long Island Sound)
- Fly high over city at 17,000 ft MSL after 1st loop and at 33,000 ft MSL at the end of 2nd loop



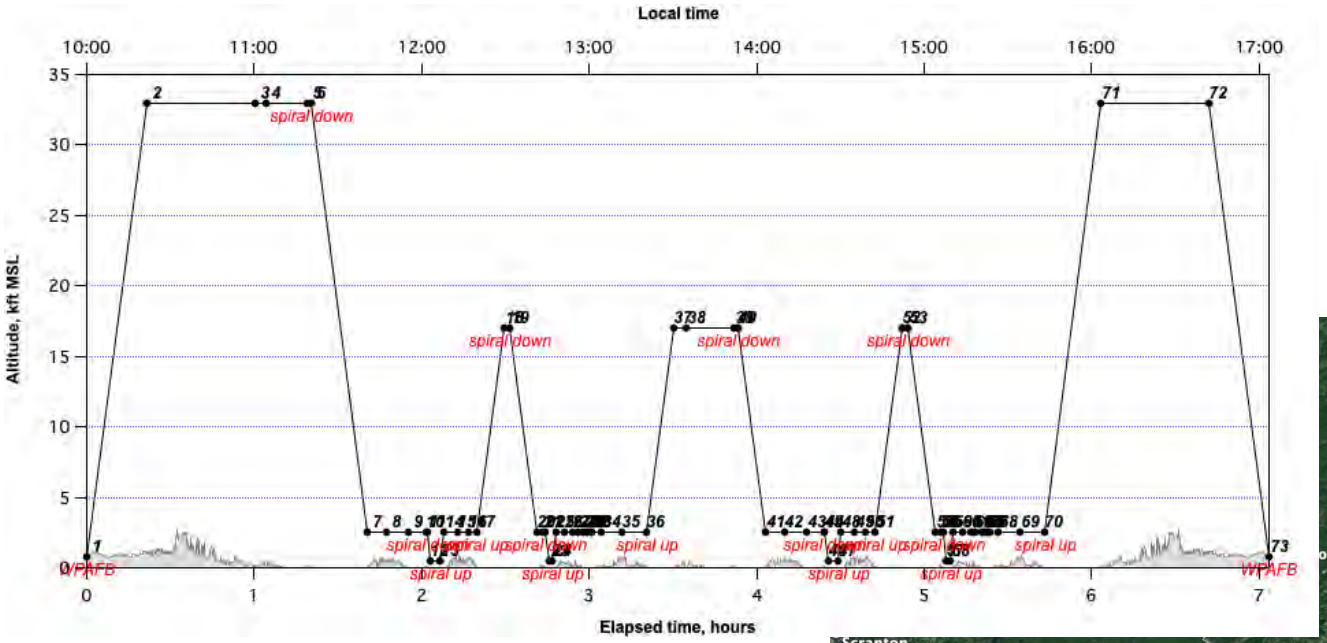
New York City: Target Goals

- Repeat the Flight Pattern 1 (Southwest) for 3 days
  - Weekday take off at 10 - 11 am
  - Weekday take off shifted later in day (1 pm to 3 pm)
    - Possible low approaches after sunset at a couple airports before RTB
  - Weekend take off at 10 - 11 am

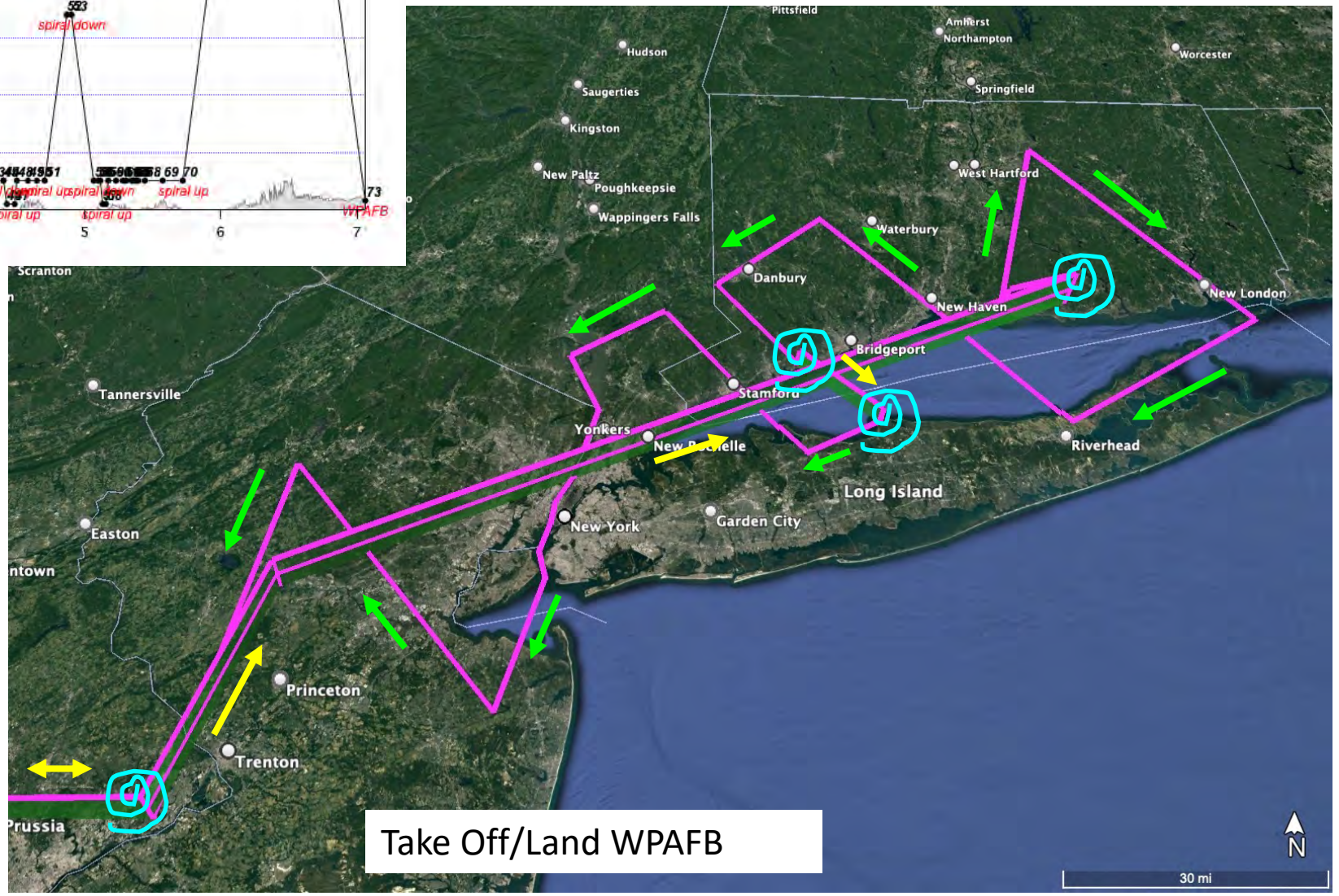


- Priorities for choosing flight days
  - 1) Cloud free
  - 2) AQI Yellow/Orange
  - 3) Multi-day event especially Friday/Saturday or Monday/Sunday, so get a clear weekend/weekday contrast under similar meteorological conditions
- The repetition of the magenta flight track provides:
  - daily variability
  - diurnal variability
  - weekend/weekday impact
- For the fourth flight, we will aim for a lower ozone condition to get variability for the model/satellites. This could be Flight Pattern 1 (Southwest or Northeast) or Flight Pattern 2 (Northwest)
  - Weekday take off at 10 - 11 am

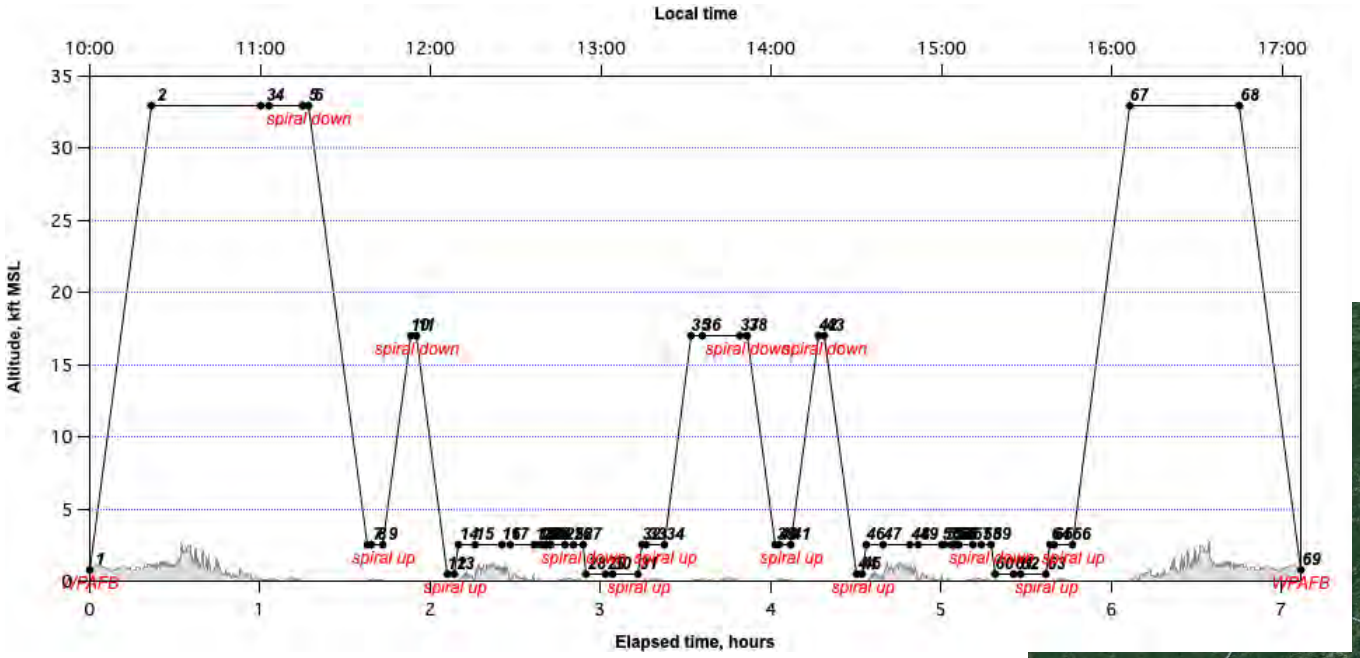
New York City: Target Flight Pattern 1 wind from the Northeast (exact same points as Southwest wind direction, but reverse all the directions – back-up)



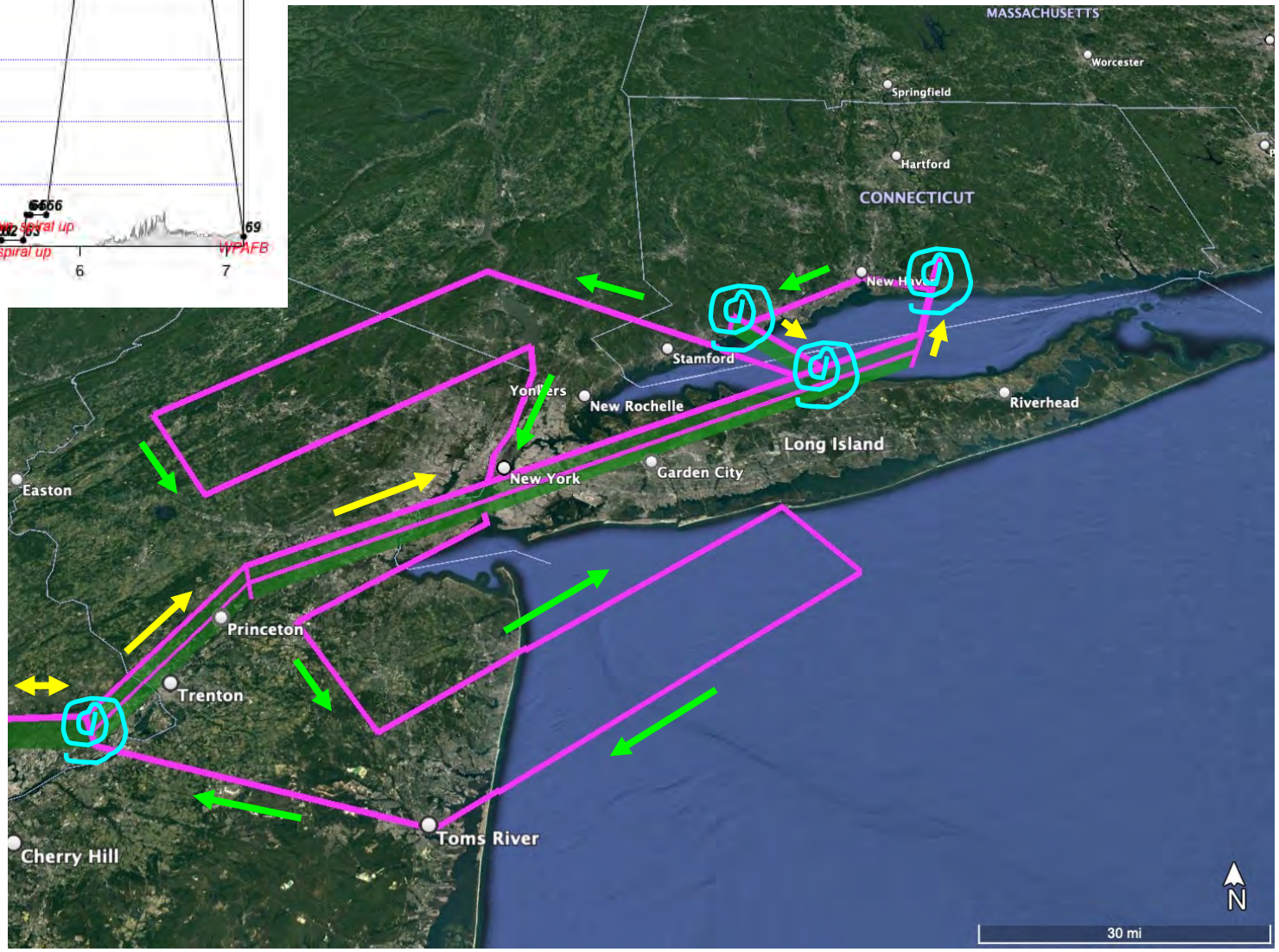
- Total flight time ~ 8 hrs
- Repeat flight plan 2 times each flight to get diurnal information
- Four spirals from 2,500 ft AGL up to 17,000 ft MSL – Bristol (Pandora), Flax Pond (Pandora,TOLNET), Westport (Pandora,TOLNET), Yale Costal Site (TOLNET)
- Rest of the flight in boundary layer as low as possible (~2,500 ft AGL land, dip to 500 ft over Long Island Sound)
- Fly high over city at 33,000 ft MSL before 1st loop and at 17,000 ft MSL before the 2nd loop



New York City: Target Flight Pattern 2 wind from the Northwest (back-up)

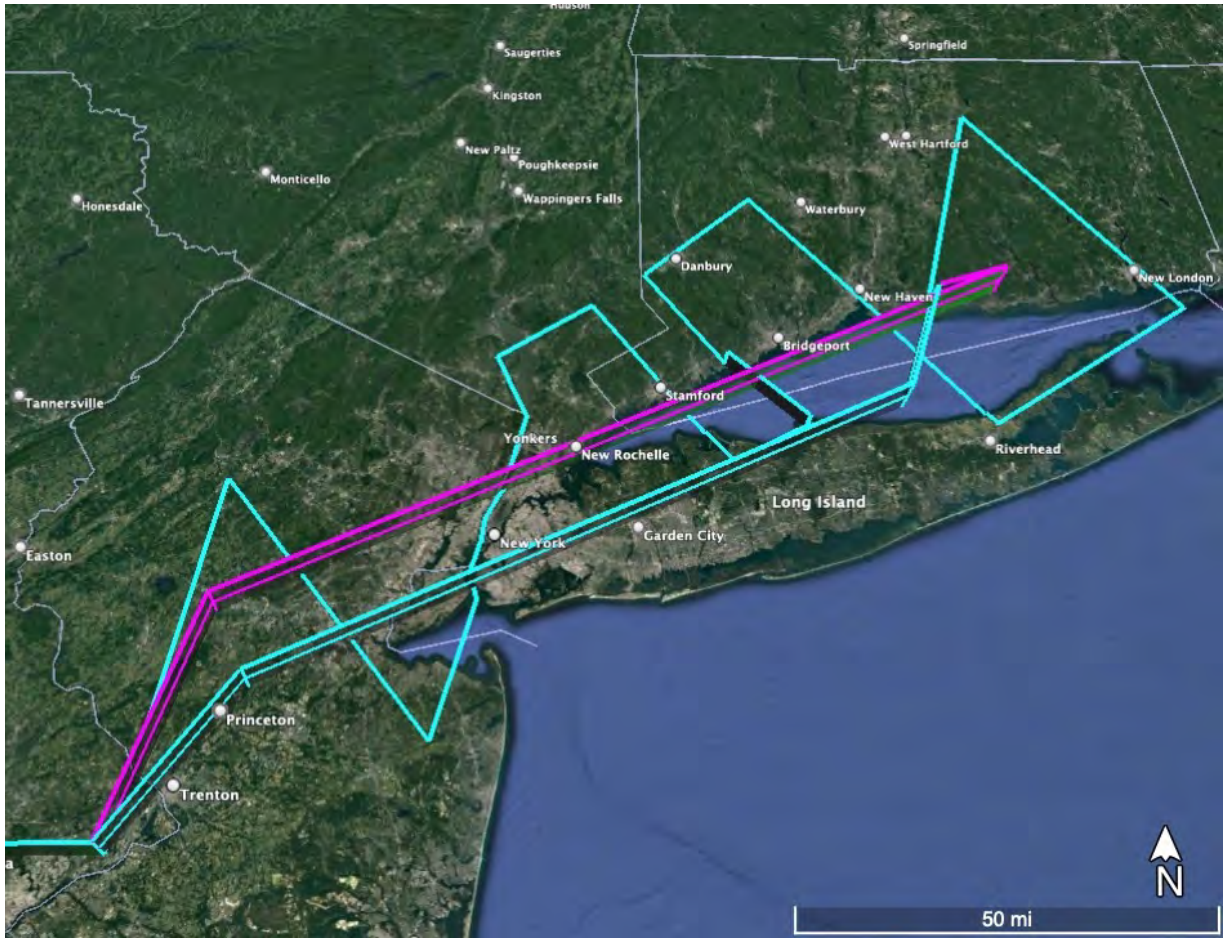


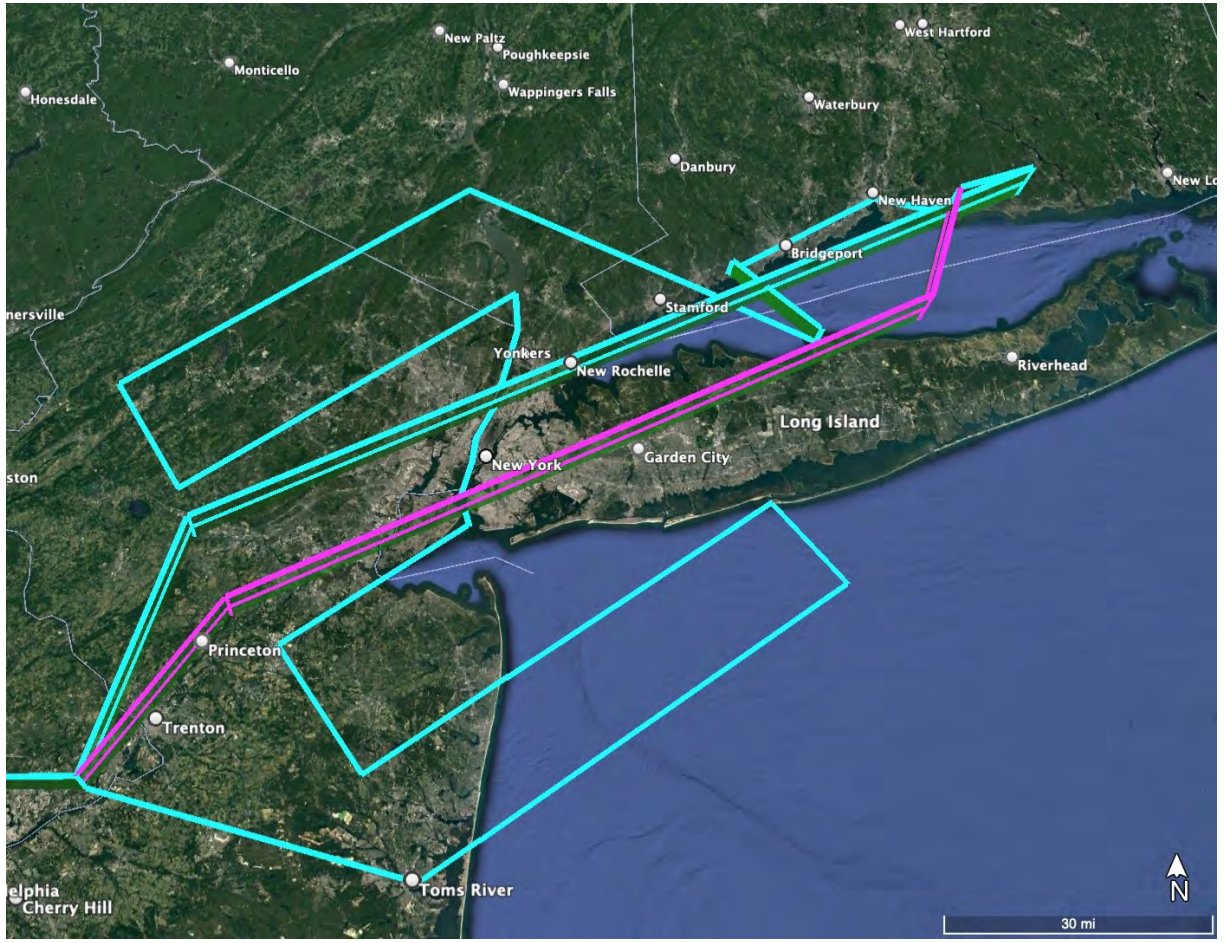
- Total flight time ~ 8 hrs
- Repeat flight plan 2 times each flight to get diurnal information
- Four spirals from 2,500 ft AGL up to 17,000 ft MSL – Bristol (Pandora), Flax Pond (Pandora,TOLNET), Westport (Pandora,TOLNET), Yale Costal Site (TOLNET)
- Rest of the flight in boundary layer as low as possible (~2,500 ft AGL land, dip to 500 ft over Long Island Sound)
- Fly high over city at 33,000 ft MSL before 1st loop and at 17,000 ft MSL before 2nd loop



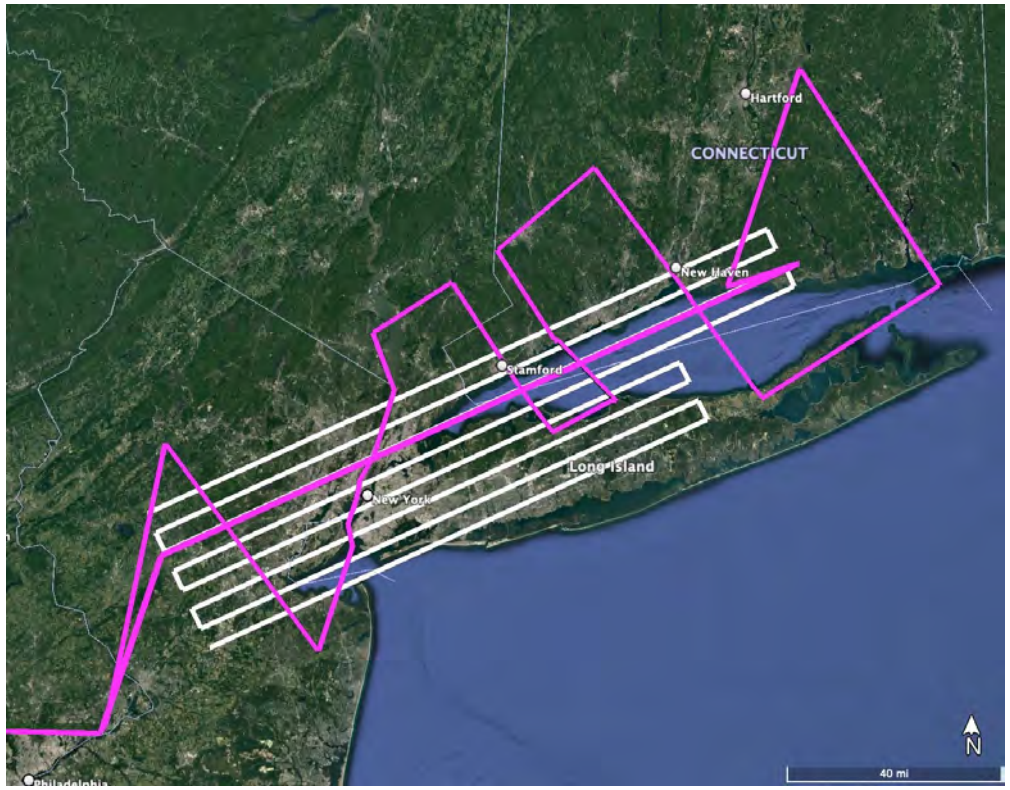
New York City: Flexibility for target Flight Pattern 1 and 2

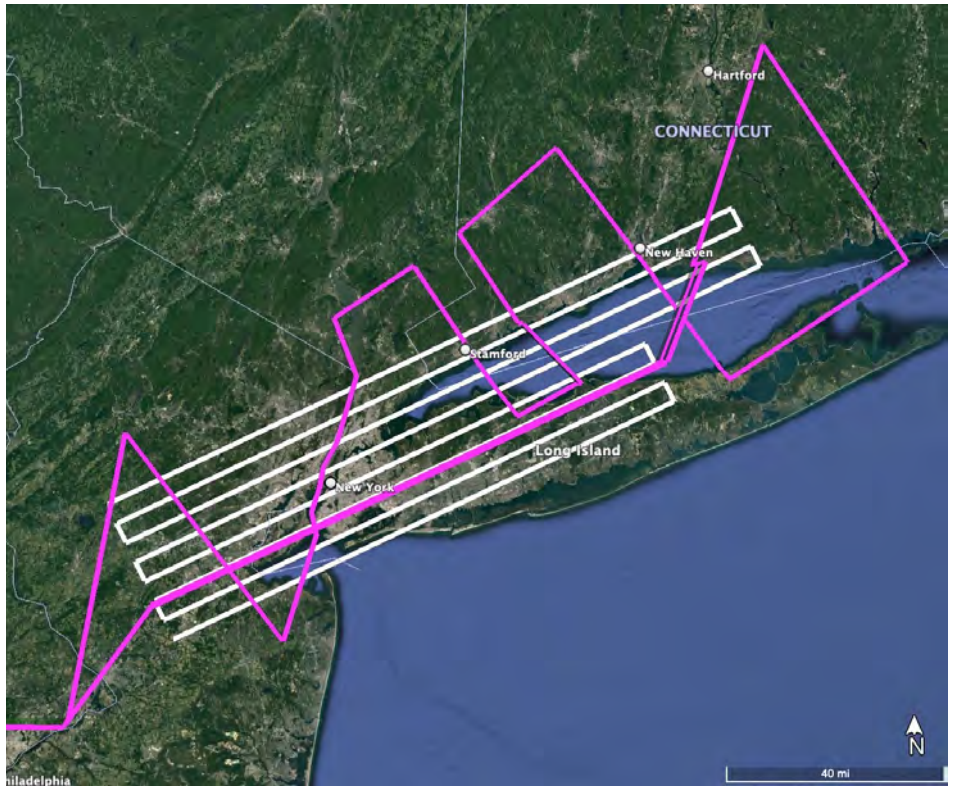
- We need slight flexibility on the upper level leg (17,000 ft or 33,000 ft) to either be on the north shore of Long Island Sound or the South shore of Long Island Sound as shown to the right.
  - This changes the location of 2 points.





Logistics: The DC8, G3, & G5 will prioritize flying on the same days





- Generally the horizontal extent will overlap between all 3 platforms.
- The DC8 will fly in the boundary layer with spirals up to 17 kft (5.2 km, FL180). The G3 (FL360) and G5 (FL280) will fly higher altitude raster patterns.
- The G3 and G5 will take off earlier in the day (~8 am) than the DC8 to prioritize having sunlight for their instruments. The DC8 will take off later (~11 am or ~1pm) to ensure that the boundary layer has fully developed. Thus, temporally there will be overlap mostly late morning to late afternoon between the different platforms.

DC8 = magenta, G5 = white

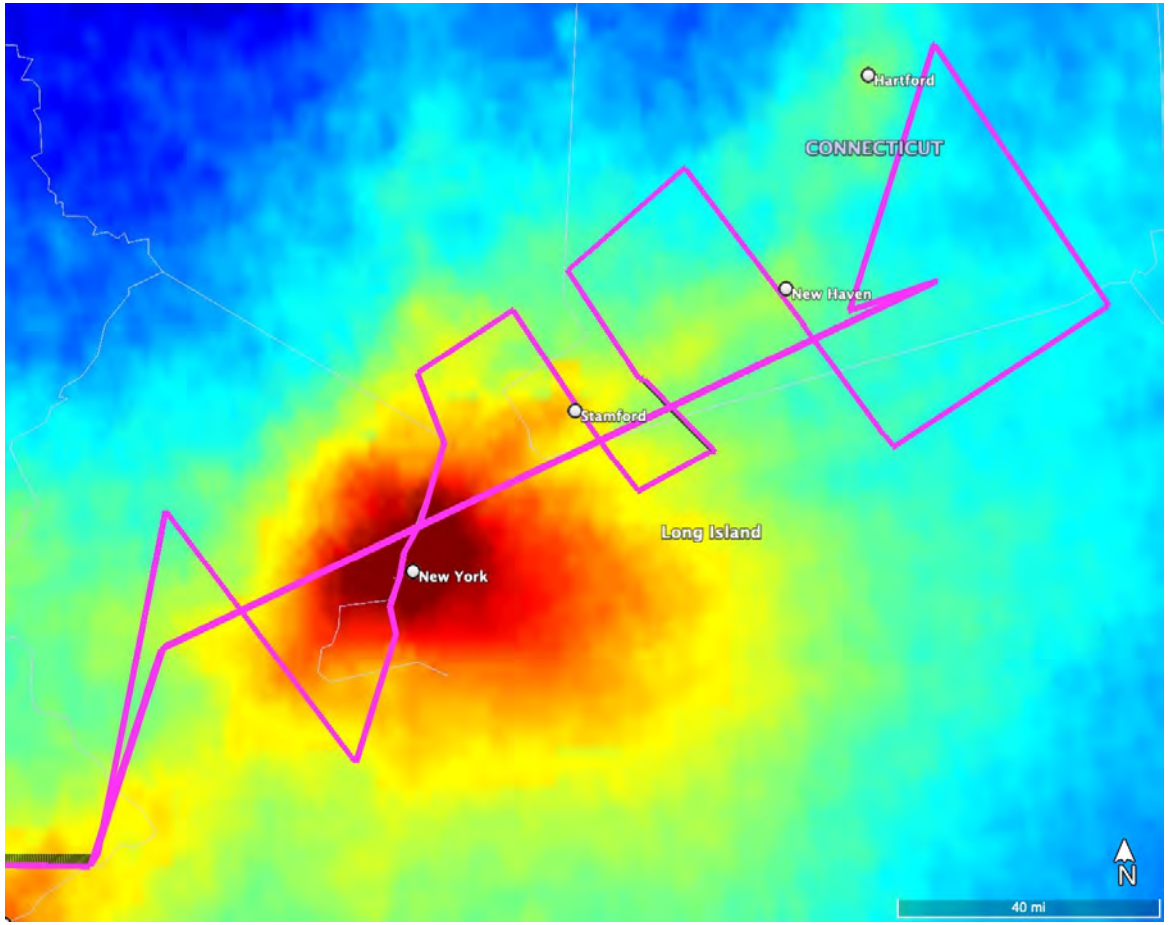
New York City: Overlap with TROPOMI

- Annual average of TROPOMI NO_2 from April 2018-March 2019 (logscale) with overlaid DC8 flight plans on top

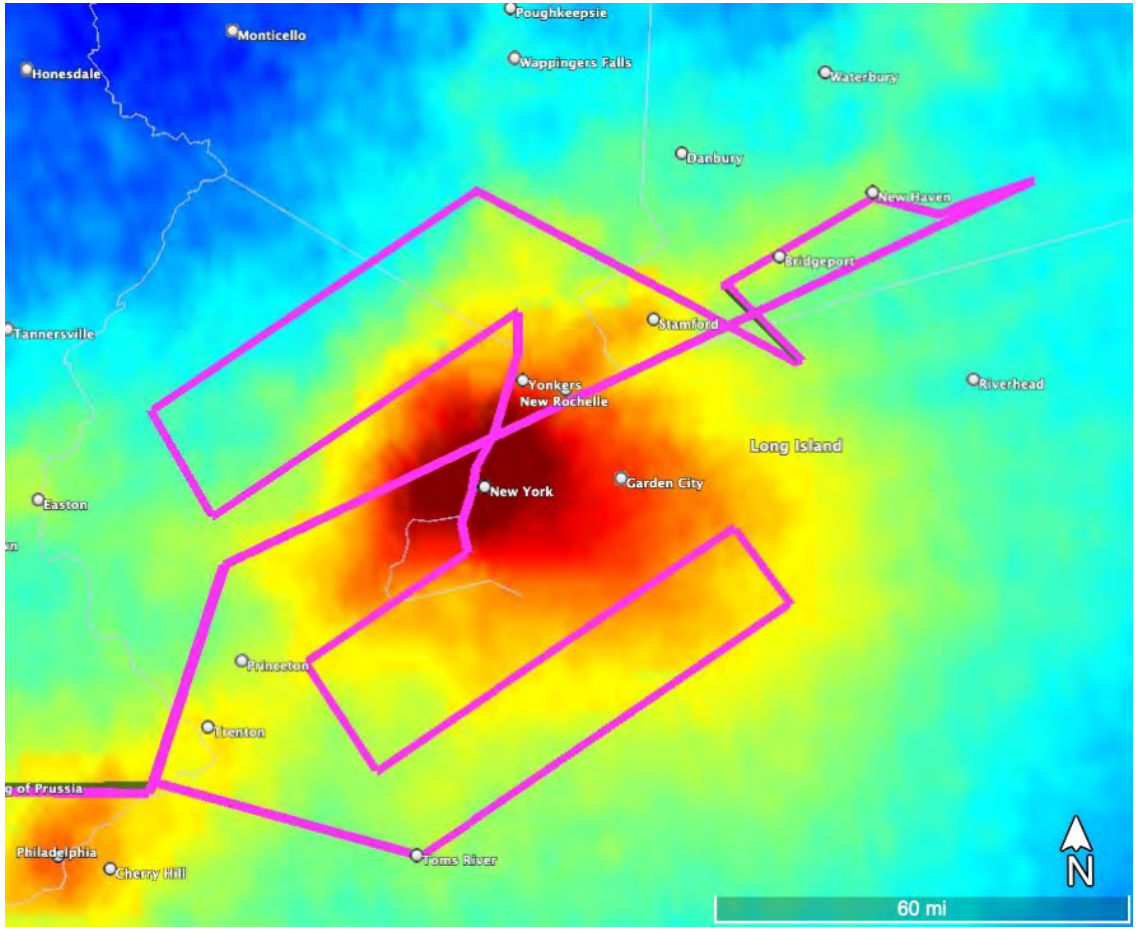
NO_2 Tropospheric Vertical Column ($x10^{14}$ molecules cm^{-2})

1 — 10

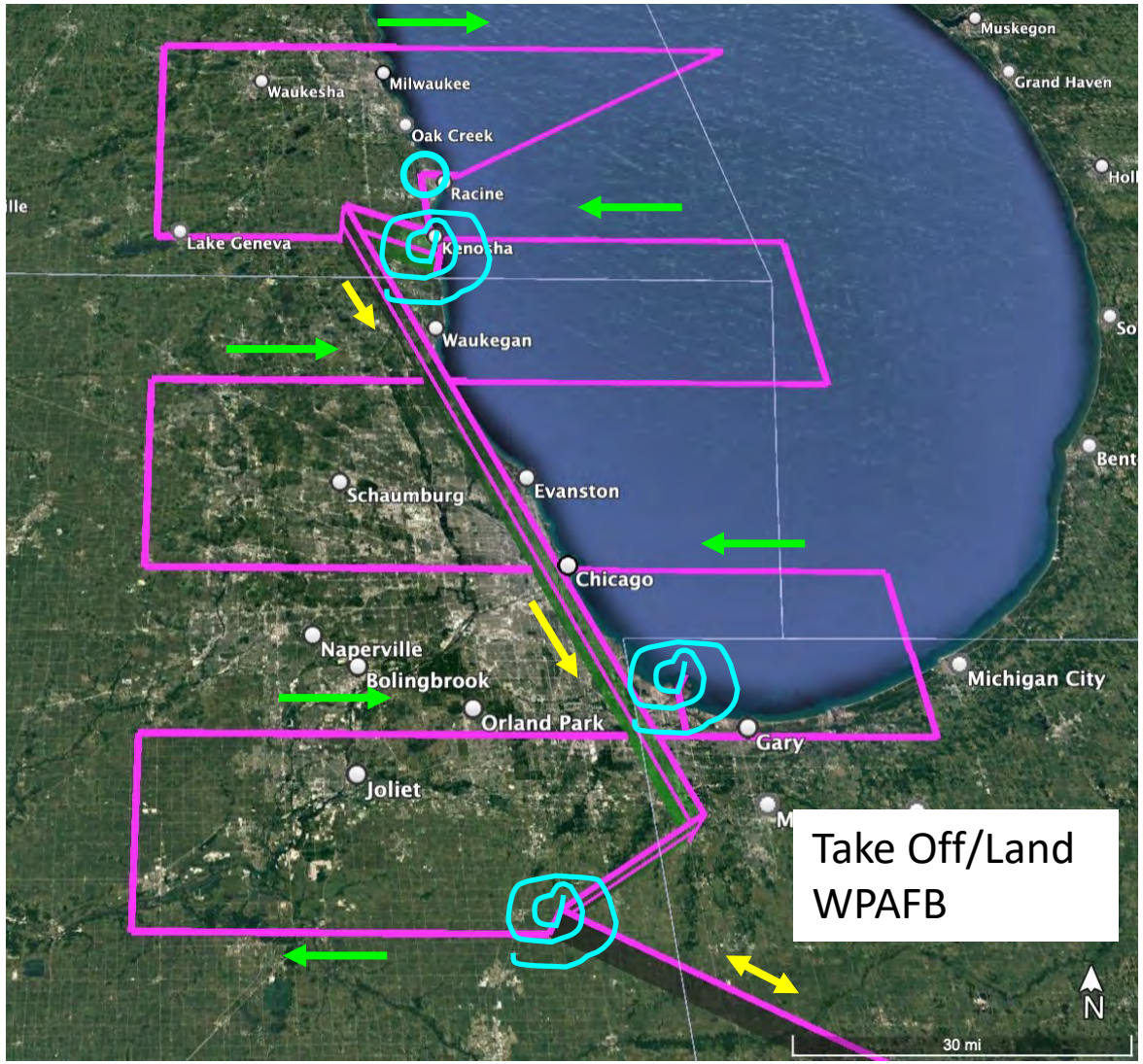
Flight Plan 1



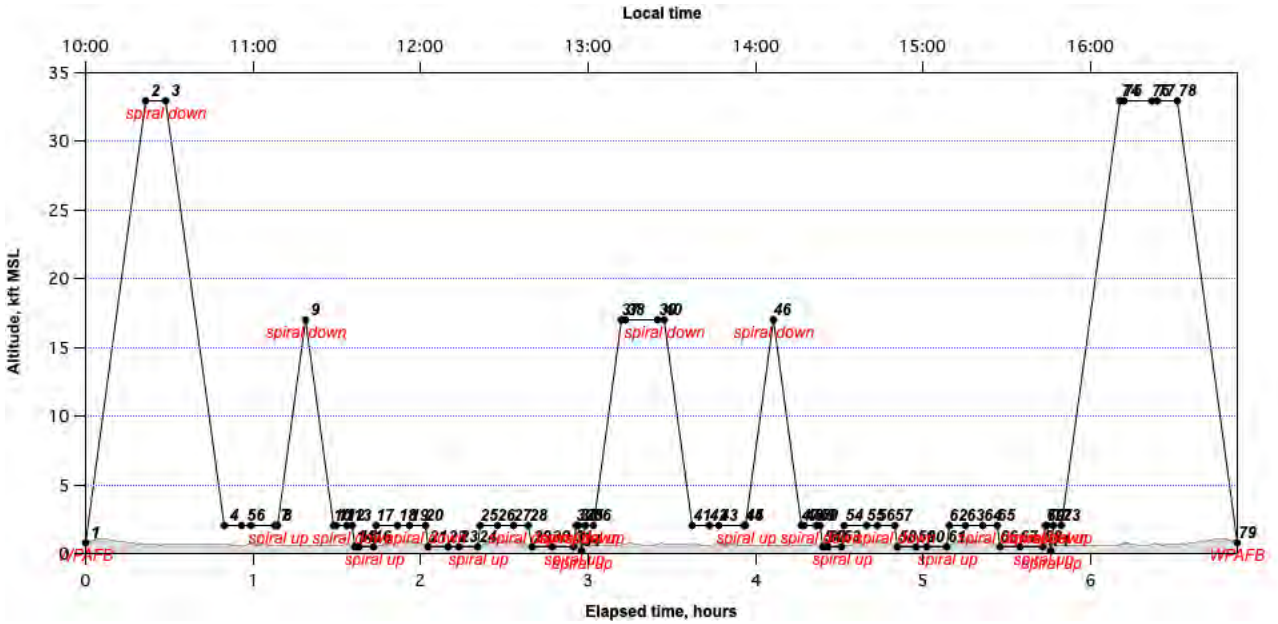
Flight Plan 2



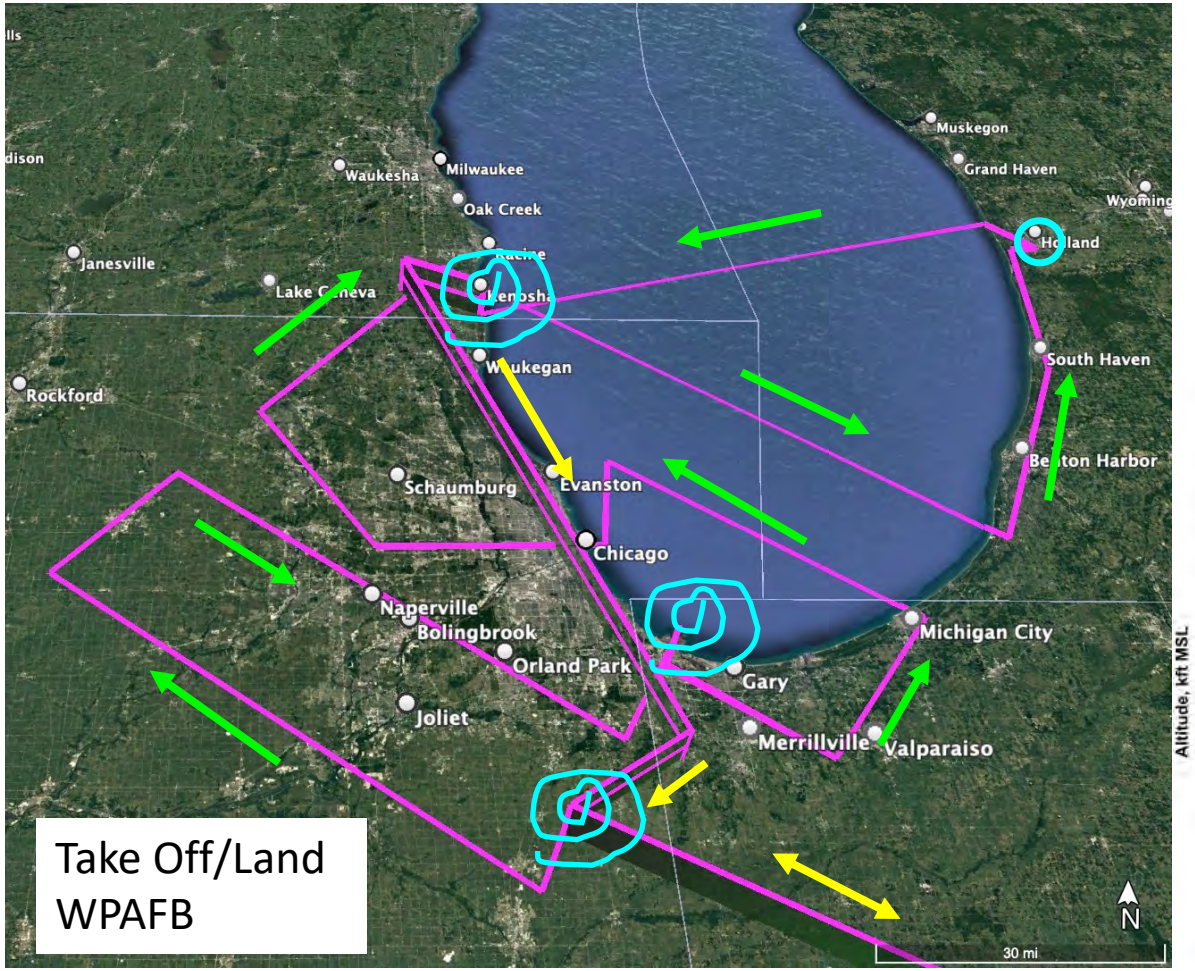
Chicago: Target Flight Pattern 1 Wind from South



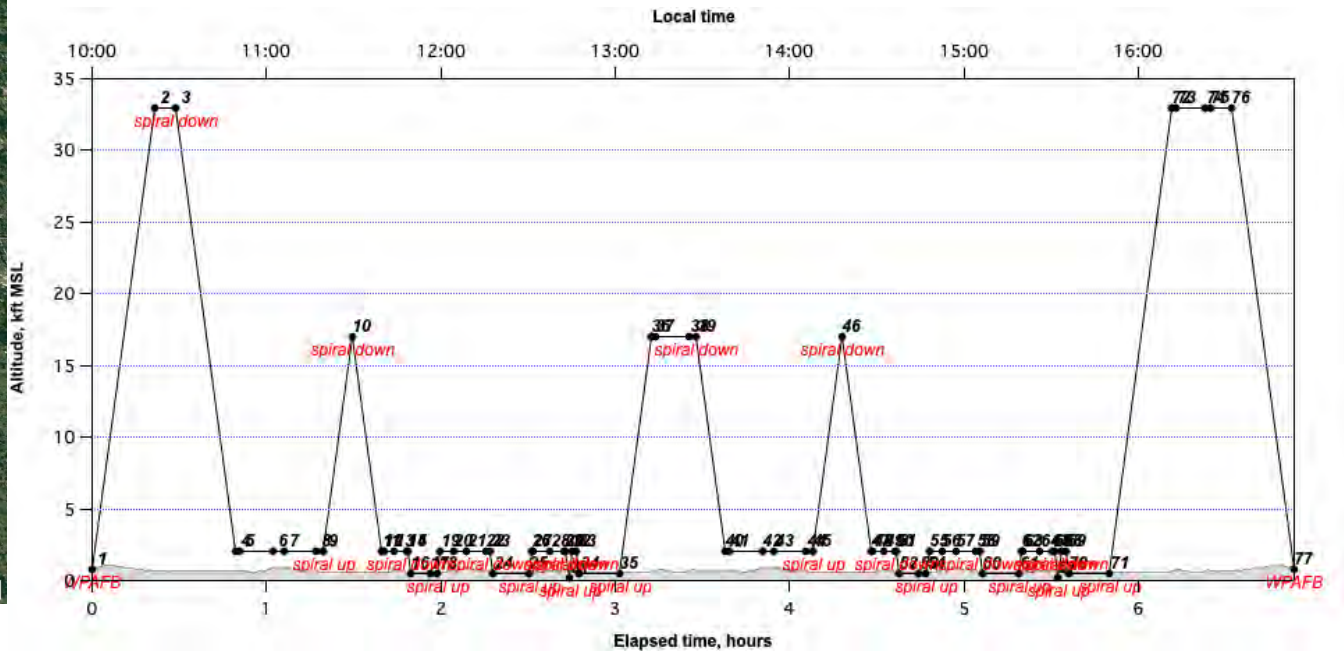
- Total flight time ~7.5 - 8 hrs
- Repeat the green arrow loop 2 times each flight to get diurnal information
- Three spirals from 2,000 ft AGL to 17,000 ft MSL – Upwind over farms, near Gary, Chiwaukee Prairie (Pandora/TOLNET, nearby AERONET)
- Rest of the flight within the boundary layer as low as possible (~2000 ft AGL land, 500 ft AGL water)
- Missed approach near the coast at RAC airport
- Fly high over city at the end of each loop at 17,000 ft MSL (1st) or 33,000 ft MSL (2nd) for SHIS.



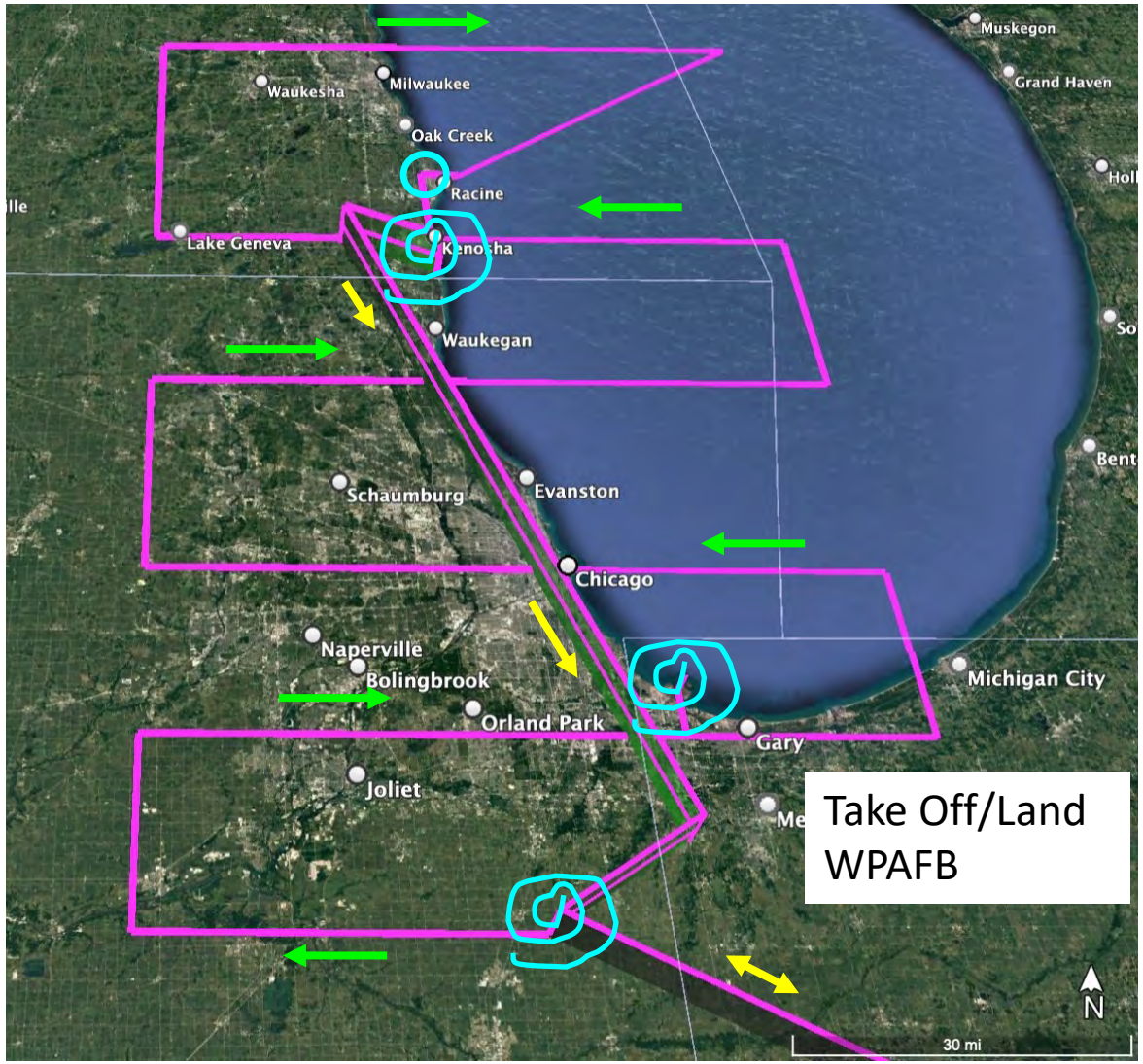
Chicago: Target Flight Pattern 2 Wind from Southwest



- Total flight time ~ 7.5 - 8 hrs
- Repeat the green arrow loop 2 times each flight to get diurnal information
- Three spirals from 2,000 ft AGL to 17,000 ft MSL – Upwind over farms, Gary, Chiwaukee Prairie (Pandora/TOLNET, nearby AERONET)
- Rest of the flight within the boundary layer as low as possible (~2000 ft AGL land, 500 ft AGL water)
- Missed approaches near the coast at Holland (BIV)
- Fly high over city at the end of each loop at 17,000 ft MSL (1st) or 33,000 ft MSL (2nd).

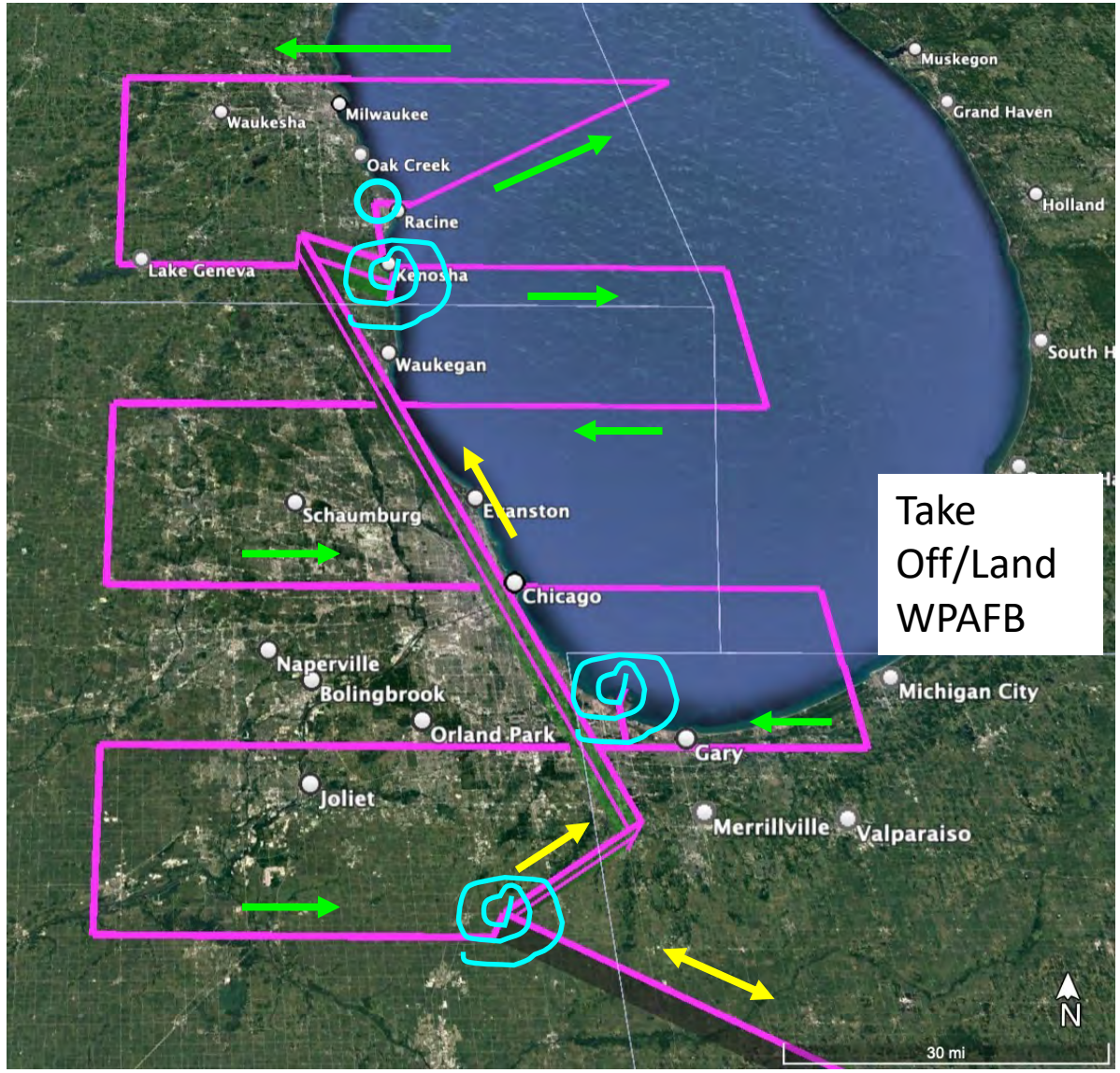


Chicago: Target Goals

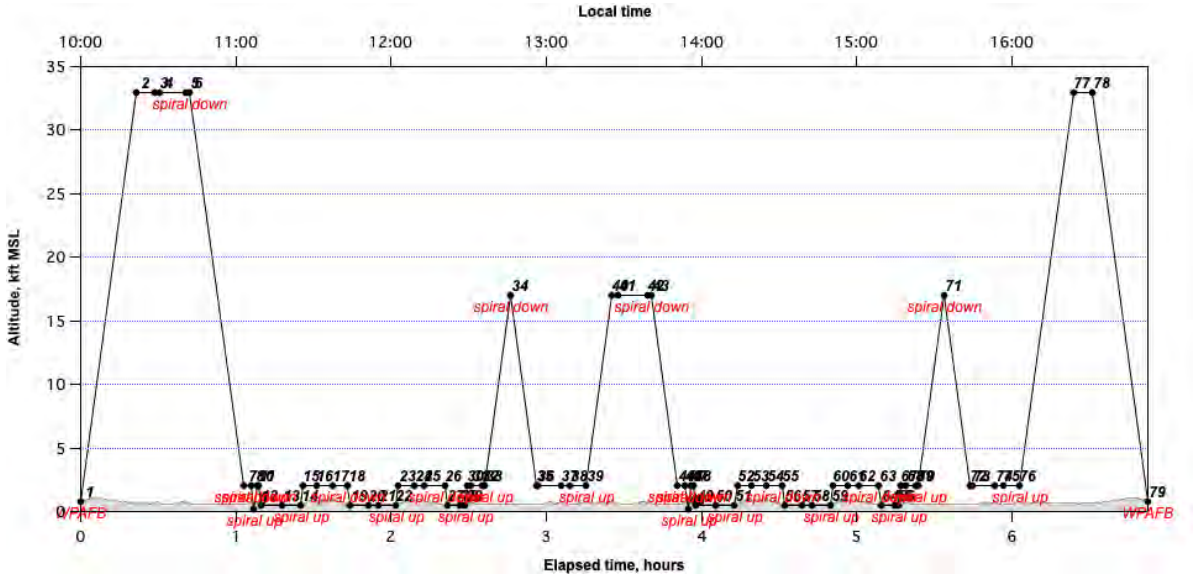


- Repeat the Flight Pattern 1 or Flight Pattern 2 for 3 days
  - 1 Weekday take off at 10 - 11 am
  - 1 Weekday take off shifted later in day (1 pm – 3 pm)
    - Possible low approaches after sunset at a couple airports before RTB
  - 1 Weekend take off at 10 - 11 am
- Priorities for choosing flight days
  - 1) Cloud free
  - 2) AQI Yellow/Orange
  - 3) Multi-day event especially Friday/Saturday or Monday/Sunday, so get a clear weekend/weekday contrast under similar meteorological conditions
- The repetition of the magenta flight track provides:
  - daily variability
  - diurnal variability
  - weekend/weekday impact
- For the fourth flight, we will aim for a lower ozone condition to get variability for the model/satellites. This could be Flight Pattern 1 (South or North) or Flight Pattern 2 (Southwest)
  - Weekday take off at 10 - 11 am

Chicago: Target Flight Pattern 1 Wind from the North (backup, exact same points as wind from the South pattern, but reverse all the directions)

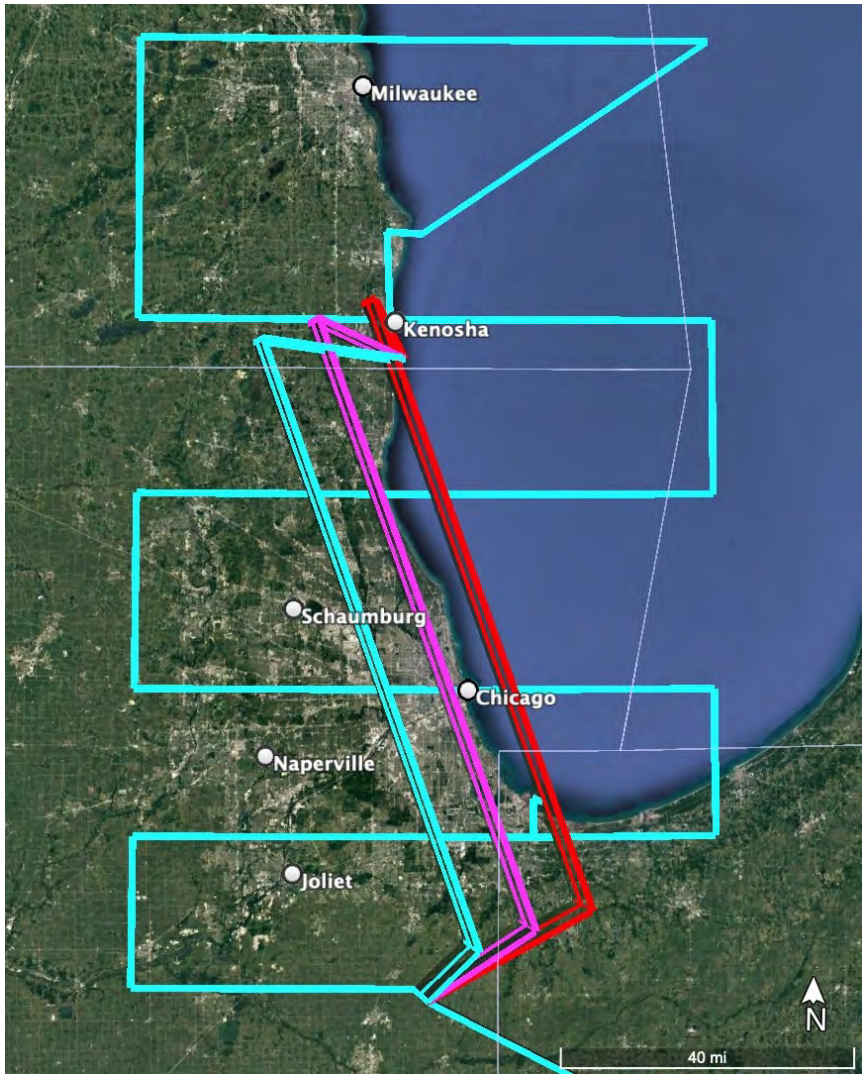


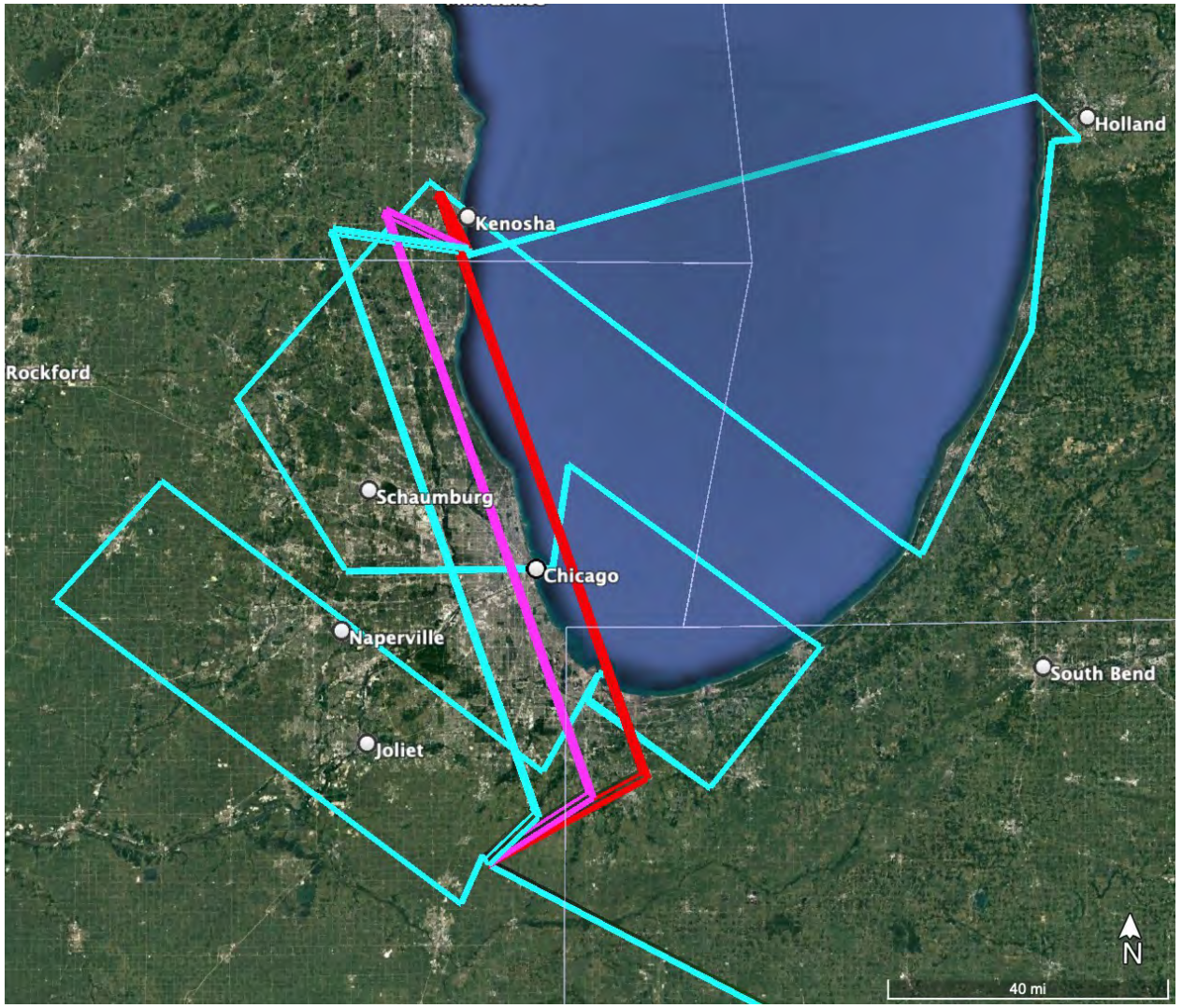
- Total flight time ~ 7.5 - 8 hrs
- Repeat the green arrow loop 2 times each flight to get diurnal information
- Three spirals from 2,000 ft AGL to 17,000 ft MSL – Chiwaukee Prairie (Pandora/TOLNET, nearby AERONET), Gary, and upwind over farms.
- Rest of the flight within the boundary layer as low as possible (~2000 ft AGL land, 500 ft AGL water)
- Missed approach near the coast at RAC airport
- Fly high over city at the beginning of each loop at 33,000 ft MSL (1st) or 17,000 ft MSL (2nd) for SHIS.



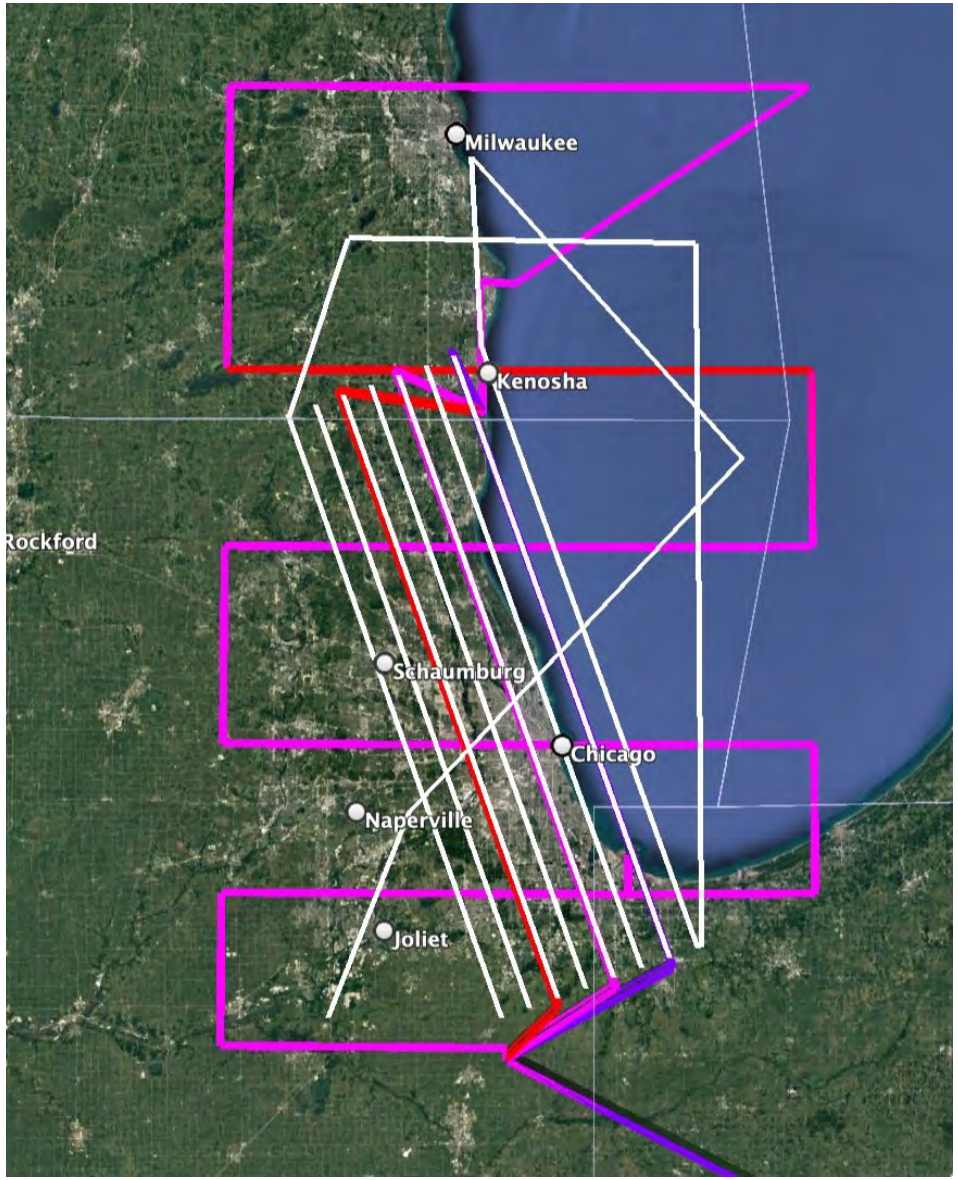
Chicago: Flexibility for target Flight Pattern 1 and 2

- We need flexibility on the upper level leg (17,000 ft or 33,000 ft) to either fly West of the city center, over the city center, or East of the city center, see figure to right
  - This changes the location of 2 points.





Logistics: The DC8, G3, & G5 will prioritize flying on the same days

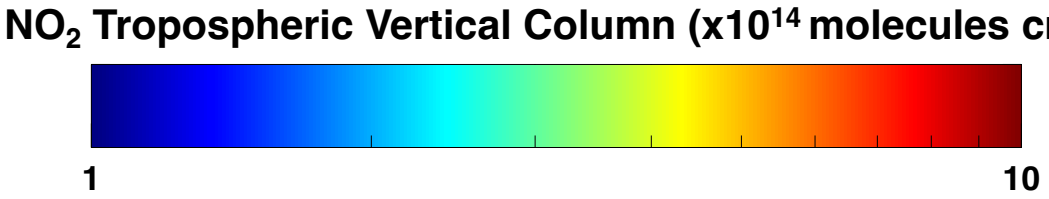


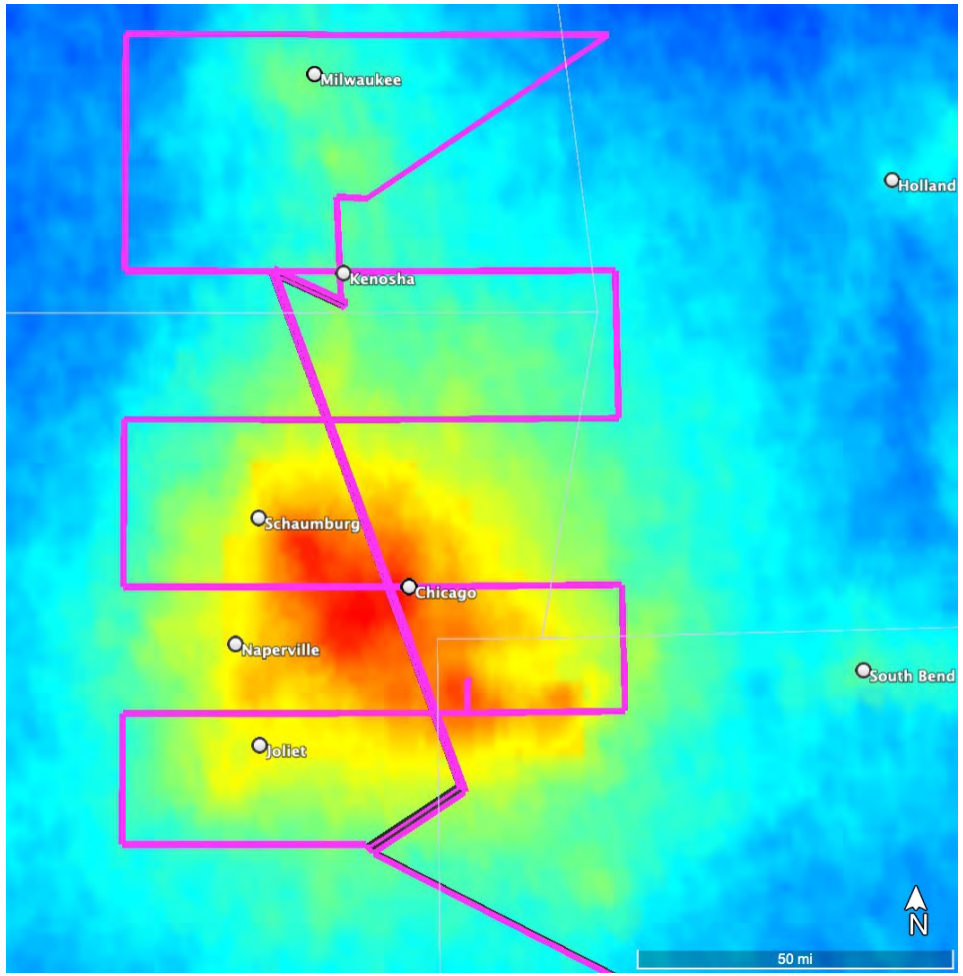
- Generally the horizontal extent will overlap between all 3 platforms.
- The DC8 will fly in the boundary layer with spirals up to 17 kft (5.2 km, FL180). The G3 (FL360) and G5 (FL280) will fly higher altitude raster patterns.
- The G3 and G5 will take off earlier in the day (~8 am) than the DC8 to prioritize having sunlight for their instruments. The DC8 will take off later (~11 am or ~1pm) to ensure that the boundary layer has fully developed. Thus, temporally there will be overlap mostly late morning to late afternoon between the different platforms.

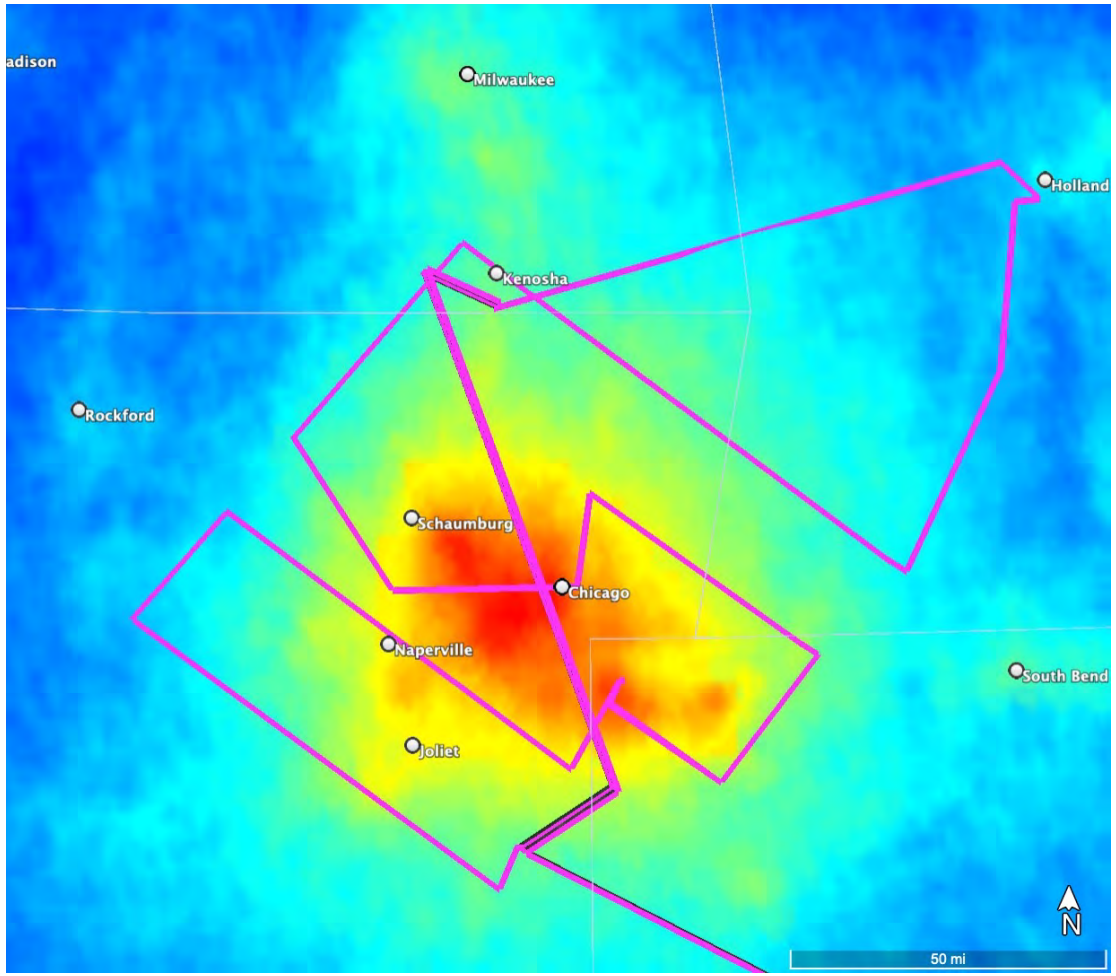
DC8 = magenta, orange, & cyan
G5 = white

Chicago: Overlap with TROPOMI

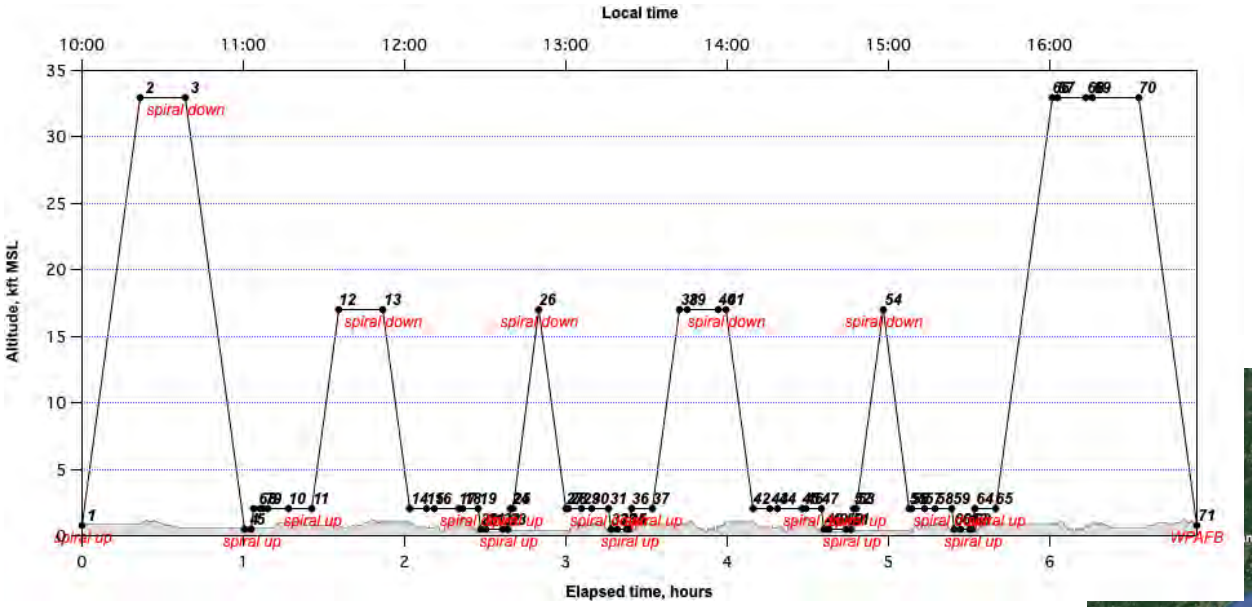
- Annual average of TROPOMI NO_2 from April 2018-March 2019 (logscale) with overlaid DC8 flight plans on top



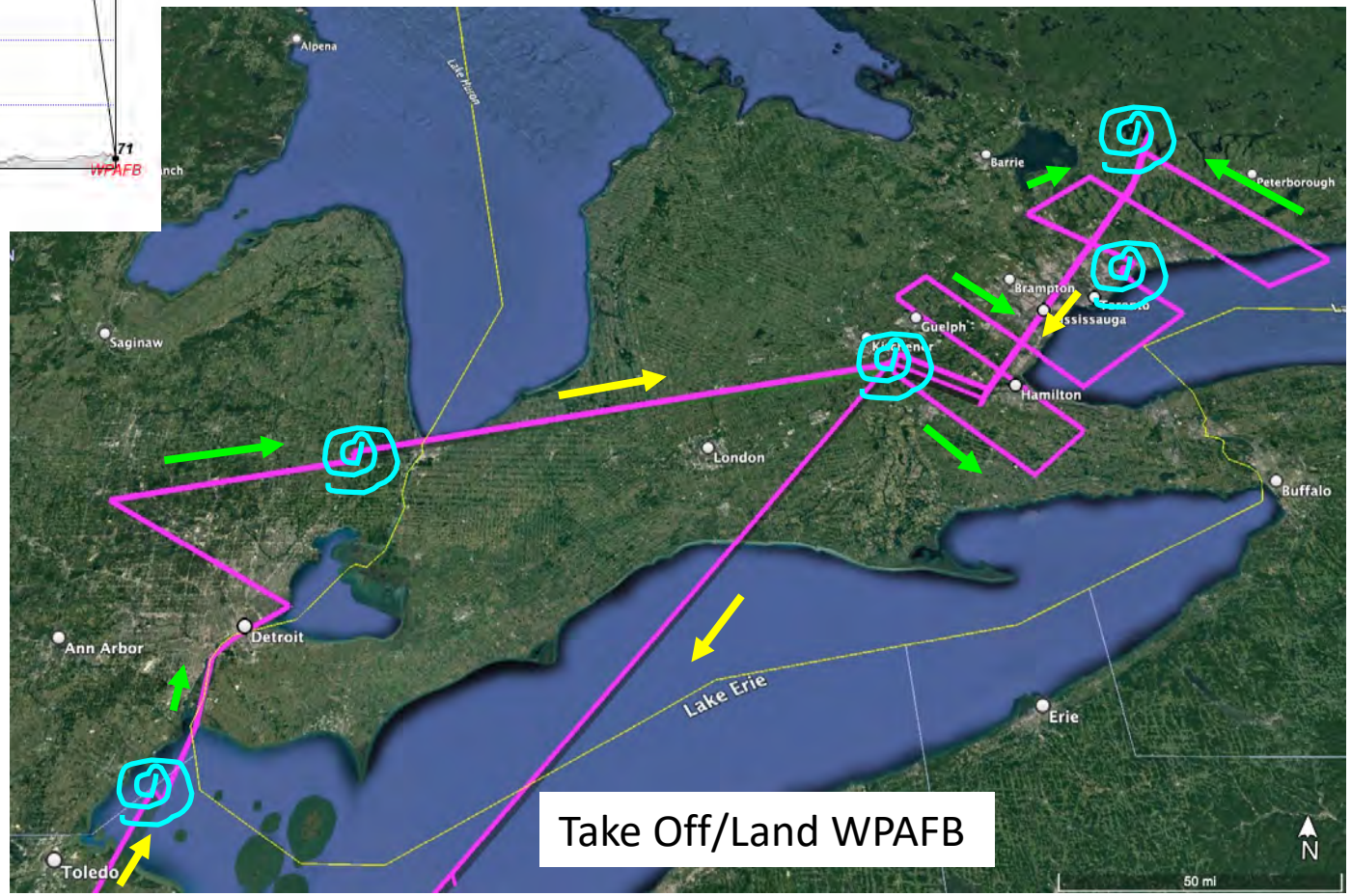




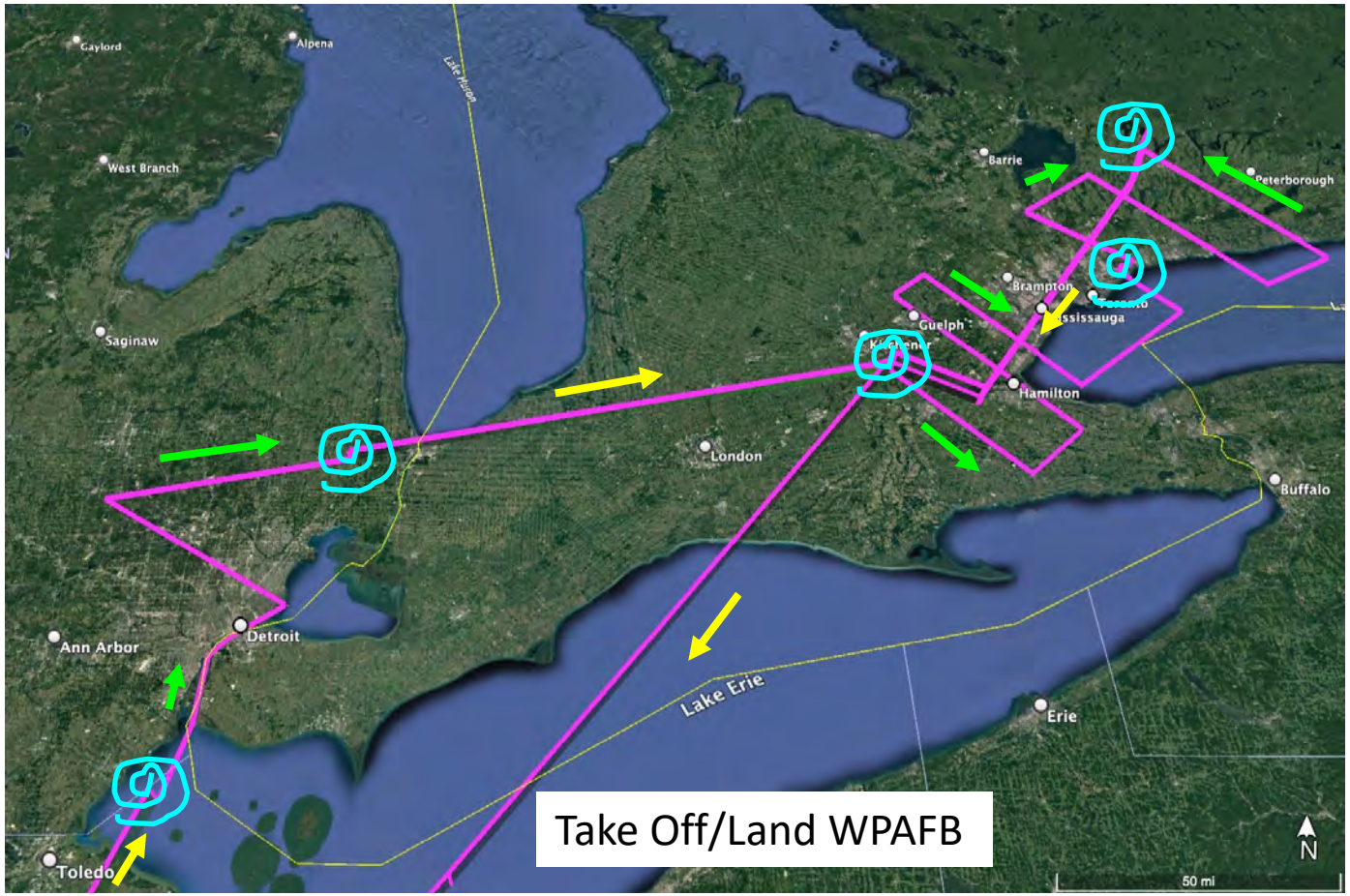
Toronto: Target Flight Pattern 1 Wind from Southwest



- Total flight time ~7.5 - 8 hrs
- Fly over Detroit only once on the way to Toronto - Spiral down in Lake Erie (AERONET)
- Repeat the green arrow loop 2 times each flight to get diurnal information
- Three spirals from 2,000 ft AGL to 17,000 ft MSL – Upwind, UT-Scarborough (Pandora), downwind
- Rest of the flight within the boundary layer as low as possible (~2000 ft AGL land, 500 ft AGL water)
- Fly high over city at the end of each loop at 17,000 ft MSL (1st) or 33,000 ft MSL (2nd) for SHIS.

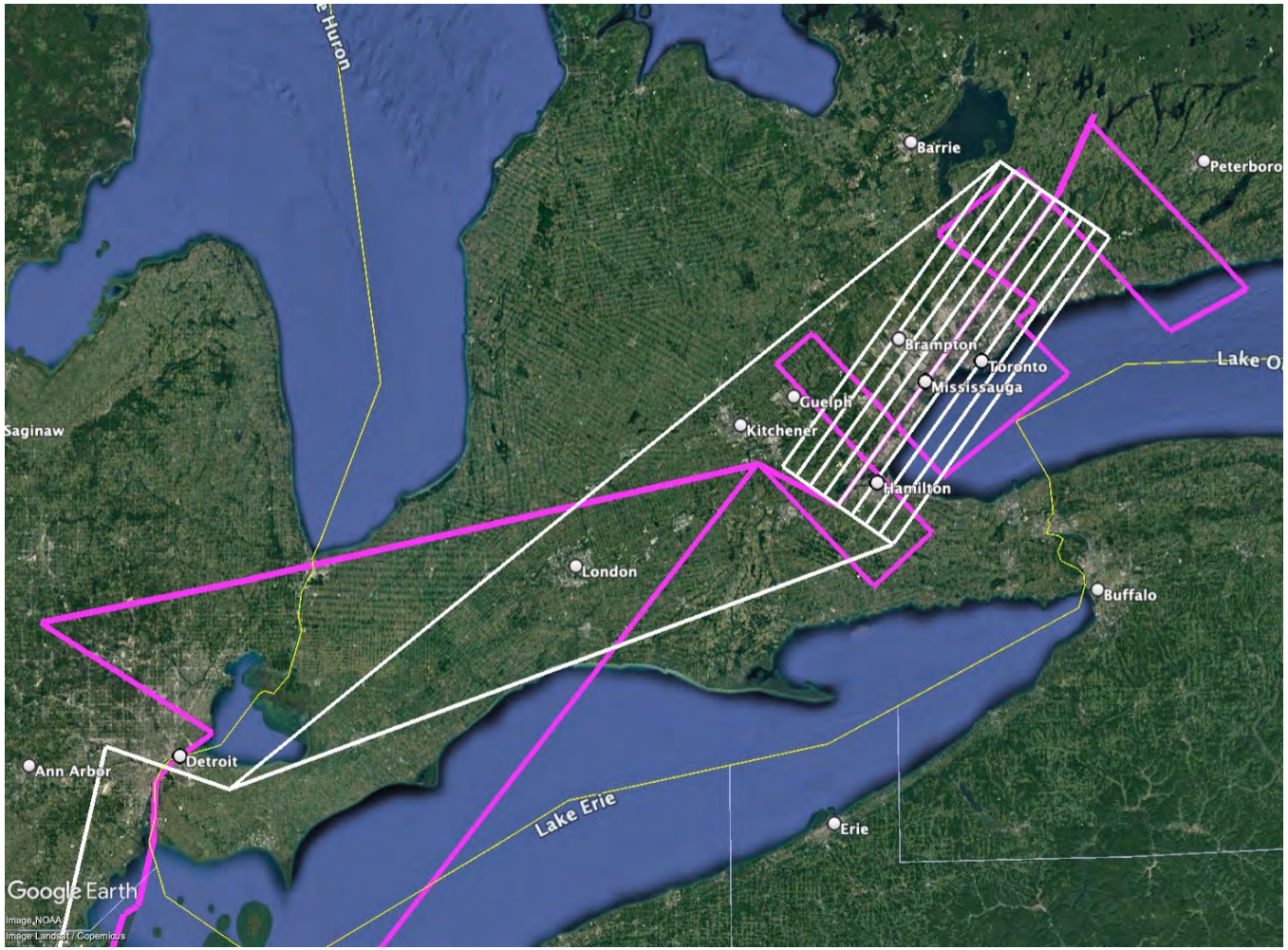


Toronto: Target Goals



- Repeat the Flight Pattern 1 for 2 days
  - 1 Weekday take off at 10 - 11 am
  - 1 Weekday take off shifted later in day (May consider flying a weekend instead depending on meteorological conditions)
- Priorities for choosing flight days
  - 1) Cloud free
  - 2) AQI Yellow/Orange
- The repetition of the magenta flight track provides:
  - daily variability
  - diurnal variability

Logistics: The DC8, G3, & G5 will prioritize flying on the same days



- Generally the horizontal extent will overlap between all 3 platforms.
- The DC8 will fly in the boundary layer with spirals up to 17 kft (5.2 km, FL180). The G3 (FL360) and G5 (FL280) will fly higher altitude raster patterns.
- The G3 and G5 will take off earlier in the day (~8 am) than the DC8 to prioritize having sunlight for their instruments. The DC8 will take off later (~11 am or ~1pm) to ensure that the boundary layer has fully developed. Thus, temporally there will be overlap mostly late morning to late afternoon between the different platforms.

DC8 = magenta, orange, & cyan
G5 = white

Toronto: Overlap with TROPOMI

- Annual average of TROPOMI NO_2 from April 2018-March 2019 (logscale) with overlaid DC8 flight plans on top