Representing Asian Summer Monsoon using Regional Refinement with MUSICA

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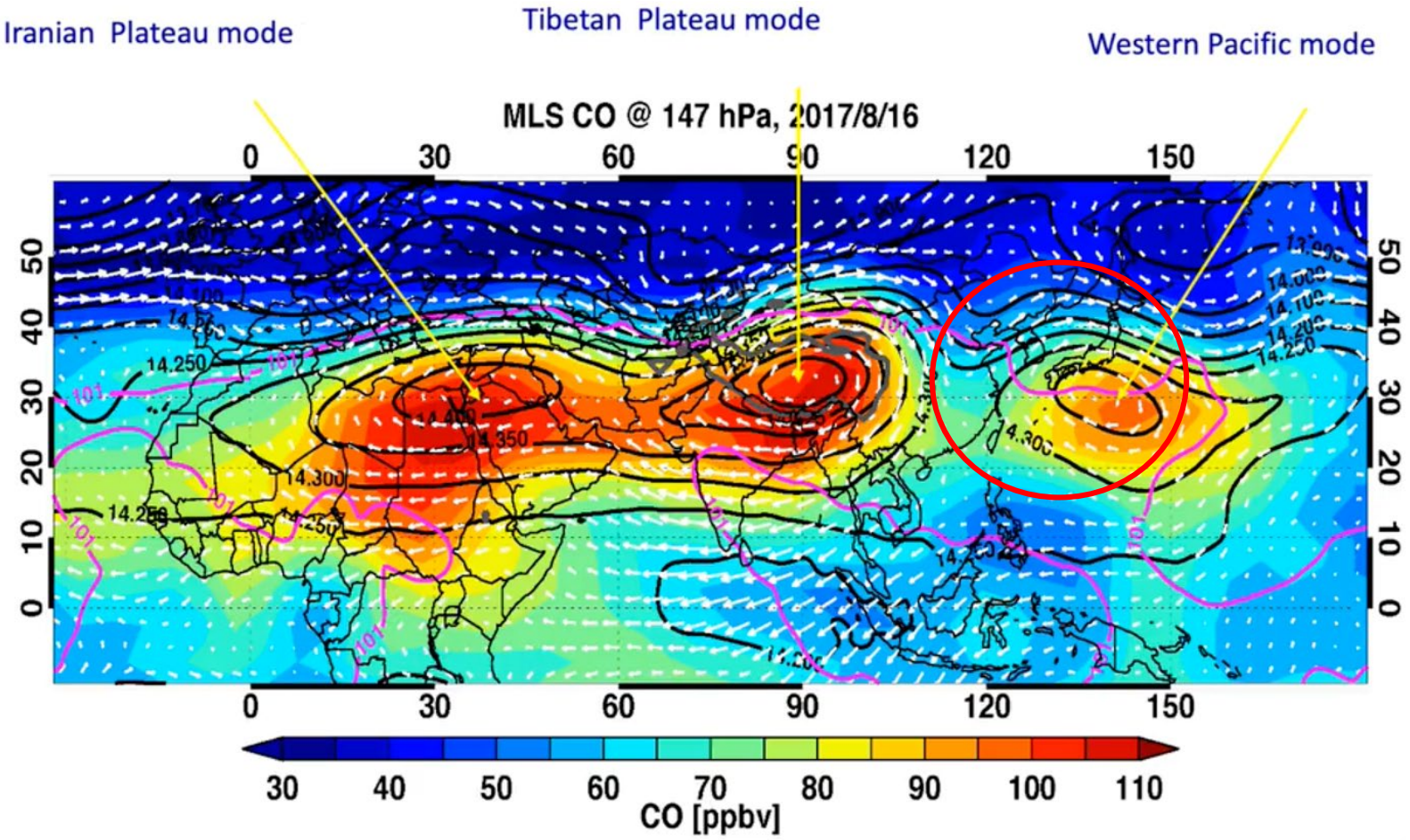
Background & Motivation of studying Asian Summer Monsoon (ASM) using MUSICA



- Largest meteorological pattern in the NH summer season.
- Efficient pathways to transport boundary layer air to the UTLS.
- **Deep convection, large-scale anticyclone and eastward shedding** – proper representation of these processes helps to characterize ASM chemistry-climate interactions.
- Provide Chemical forecast to support Asian Summer Monsoon Chemical and Climate Impact Project (**ACCLIP**) mission objectives – with a focus on **West Pacific region**.

Figure courtesy of Laura Pan, NCAR

Asian summer monsoon Chemical and Climate Impact Project (ACCLIP)

ACCLIP is designed to provide in-situ measurements necessary for addressing the science questions of ASM chemistry-climate impact.

Chemistry in the ASM outflow

➢Tracers of transport

- Anthropogenic & Natural sources

➢Ozone chemistry and budget

- Ozone depletion substances: long-lived and short-lived chlorine and bromine gases
- Ozone precursors: NMHC, OVOC, NOx (lightning/combustion)

➢Chemistry-Climate interaction

- Short-lived climate pollutants
- Aerosol precursors and aerosol formation/transport/interaction

Regional Refinement for ASM

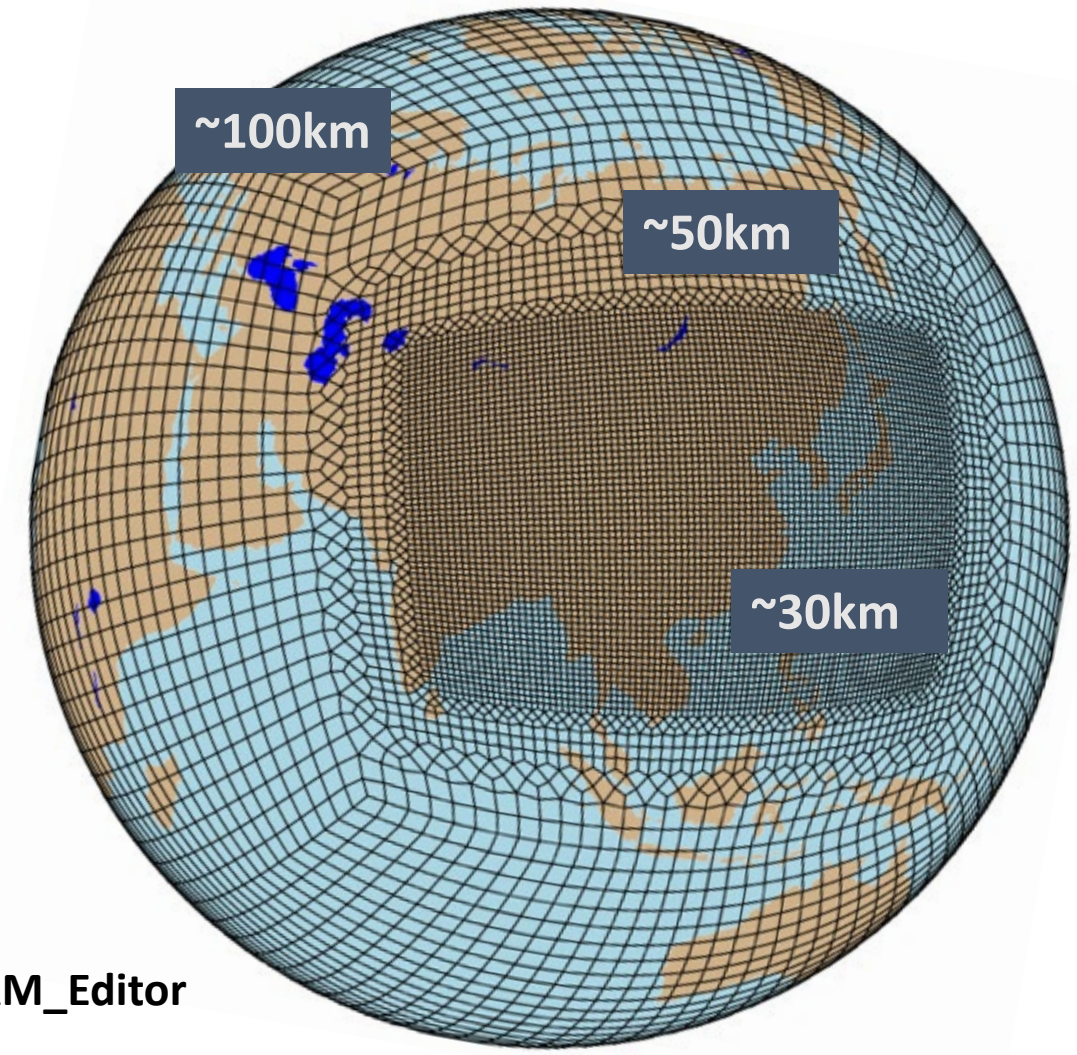


Figure courtesy of Shawn Honomichl, NCAR

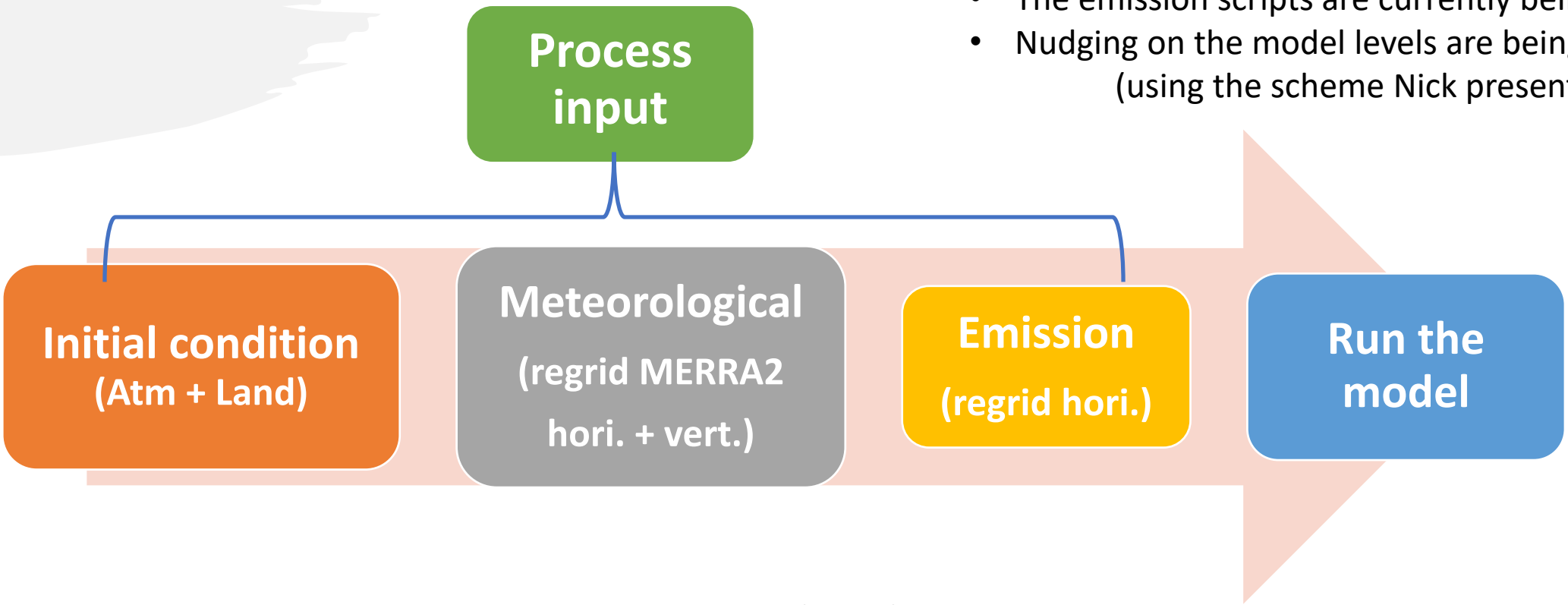
CESM2.2 CAM6-chem with 32L (MUSICA V0)

- Cube sphere grid; SE dycore; resolution around 1 degree down to a fine resolution of 0.25 degree.
- Cover the ASM deep convection; anticyclone over the Tibetan Plateau and eastward eddy shedding over the WP region.
- Allows for better representation of regional processes and chemistry of surface emissions.
  - At finer resolution, emissions and chemistry are more accurately represented.
- Include both natural and anthropogenic emission sources from South and East Asia.
  - Pollutants are simulated on human exposure-relevant scales.

Modeling Steps

https://wiki.ucar.edu/display/MUSICA/MUSICA+version+0
https://github.com/NCAR/IPT

- The emission scripts are currently being updated.
- Nudging on the model levels are being performed (using the scheme Nick presented on Monday).



Atm: spun-up CAMchem run using SE ne30 (1deg)
Land: CAM SE ne30 1deg model to spinup the land initial conditions

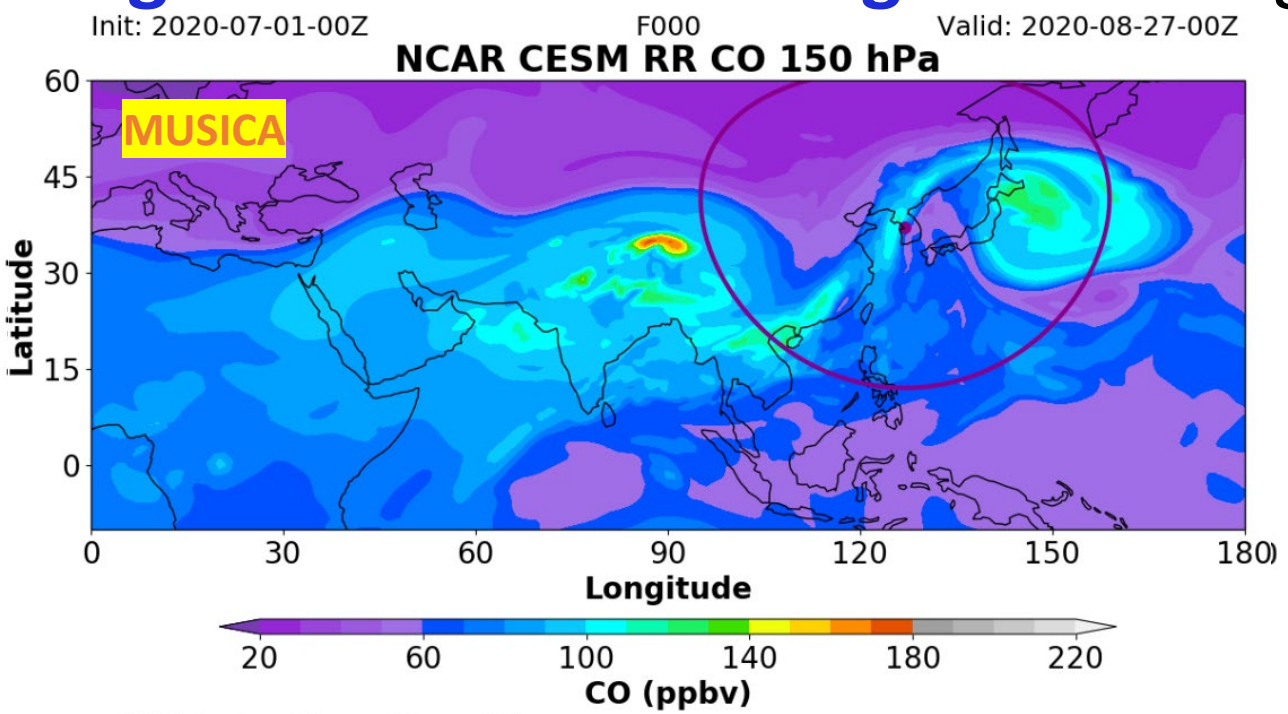
2020-07 to 2020-08 to reproduce the dry run period in 2020 for ACCLIP campaign and compare with other model results.

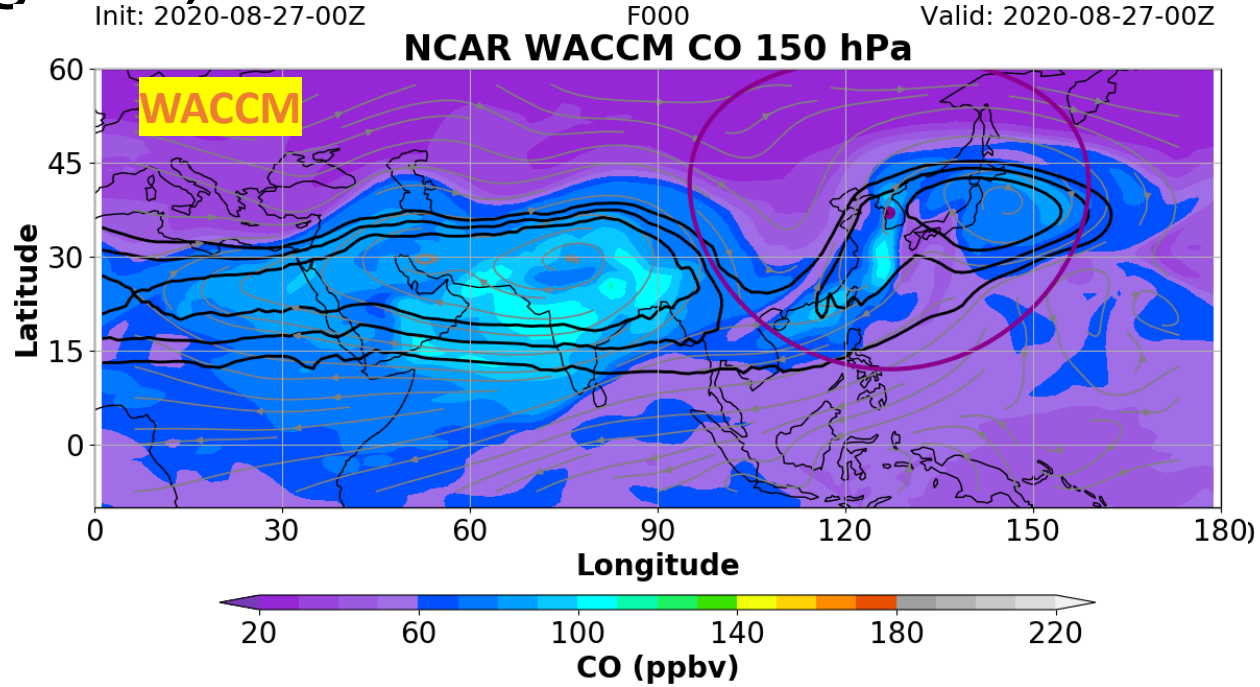
- Model cost: 150k per year

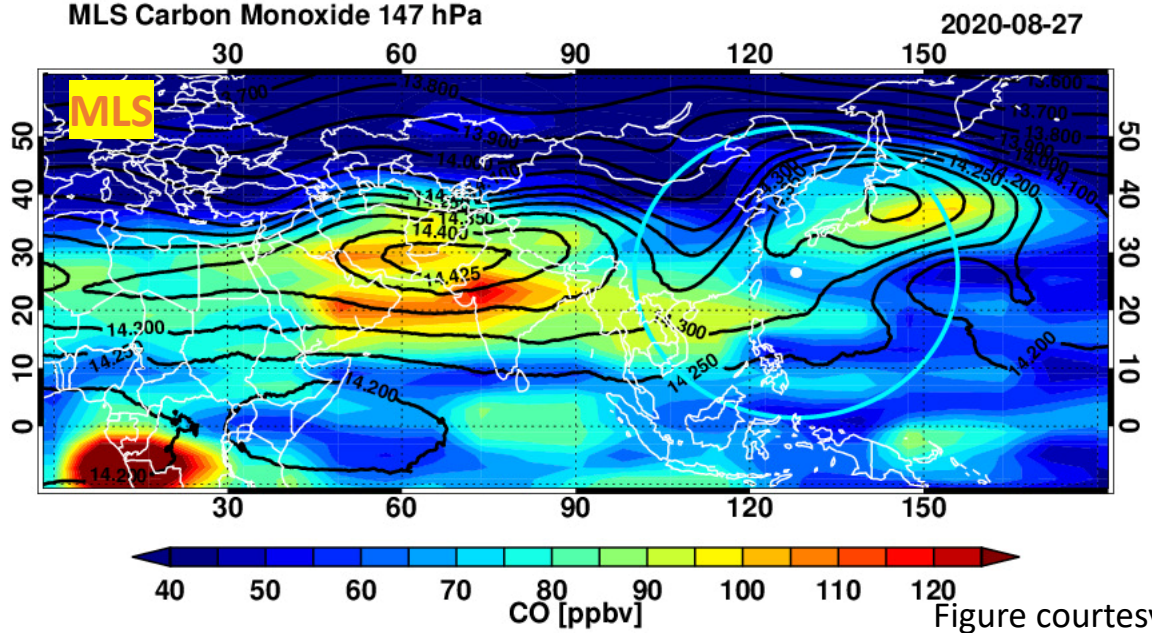
Compare MUSICA to Models used in 2020 dry run period

Model System	Resolution	Chemistry	Aerosol
NCAR CESM2 MUSICA	0.25 to 1 deg, 32L, surf to 45 km ~1km vertical res. in UTLS ~30km horizonal res.	TS1 Interactive chemistry	MAM4 (modal)
NCAR CESM2 WACCM6-SD / GEOS5	1-deg, 88L, surf to 140km ~1km vertical res. in UTLS ~100km horizontal res.	TSMLT Interactive Chemistry 240 species	MAM4 (modal)
NASA GEOS	0.25 deg, 72L, surf to 80 km ~1km vertical res. in UTLS ~30km horizonal res.	Specified Oxidants (OH, H_2O_2, NO_3 from GMI)	GOCART (Bulk)

Large Eastward Shedding Event : Aug 27th, 2020







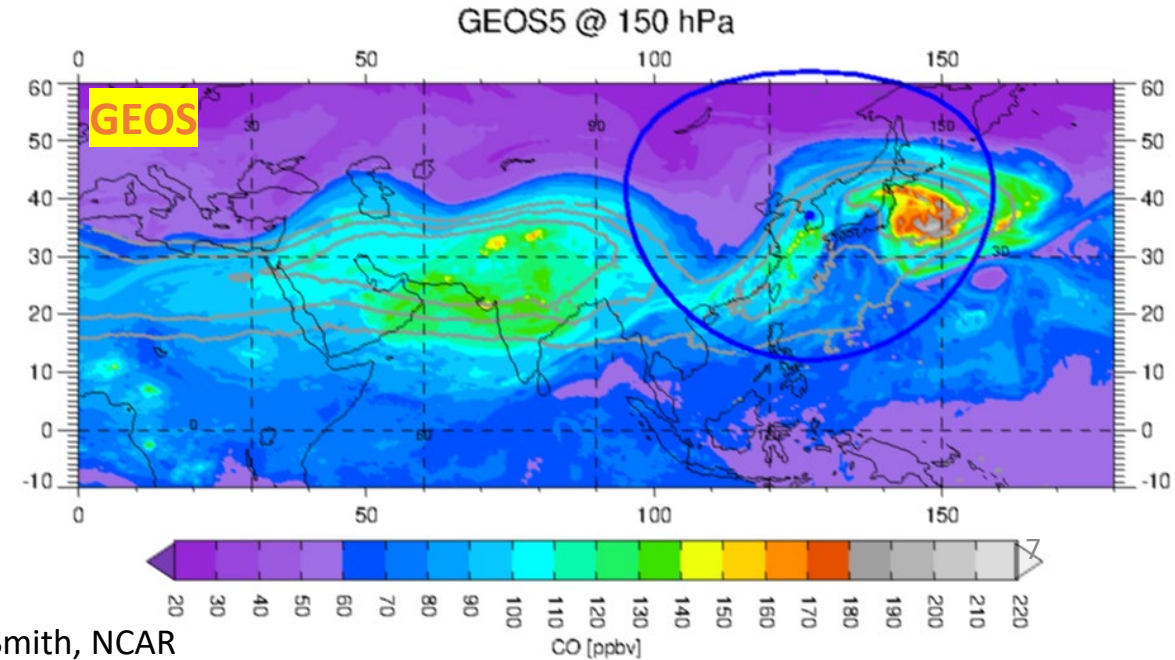


Figure courtesy of Ren Smith, NCAR

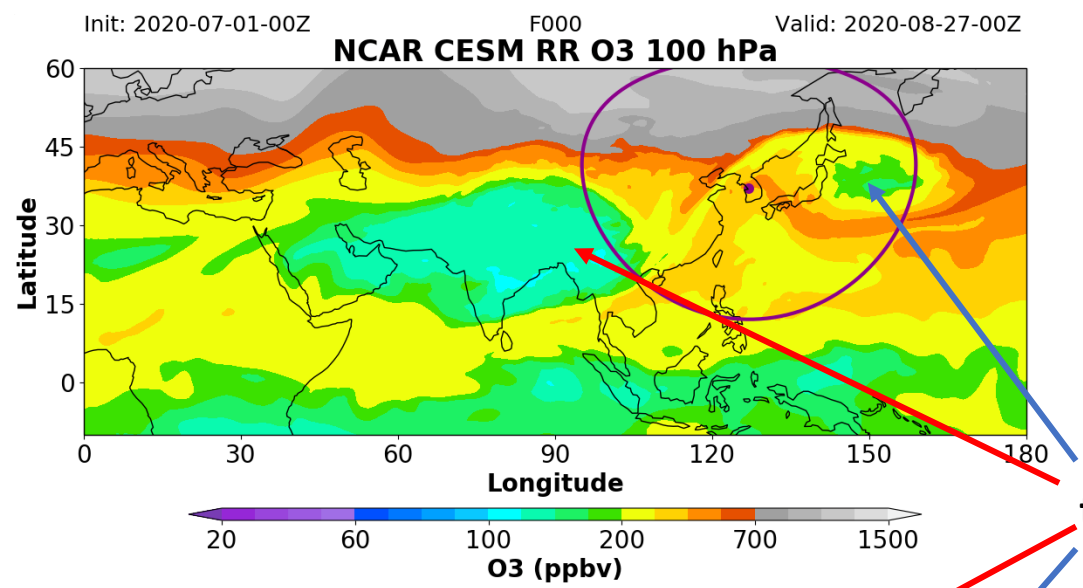
O_3 in the shedding event: Aug 27th, 2020

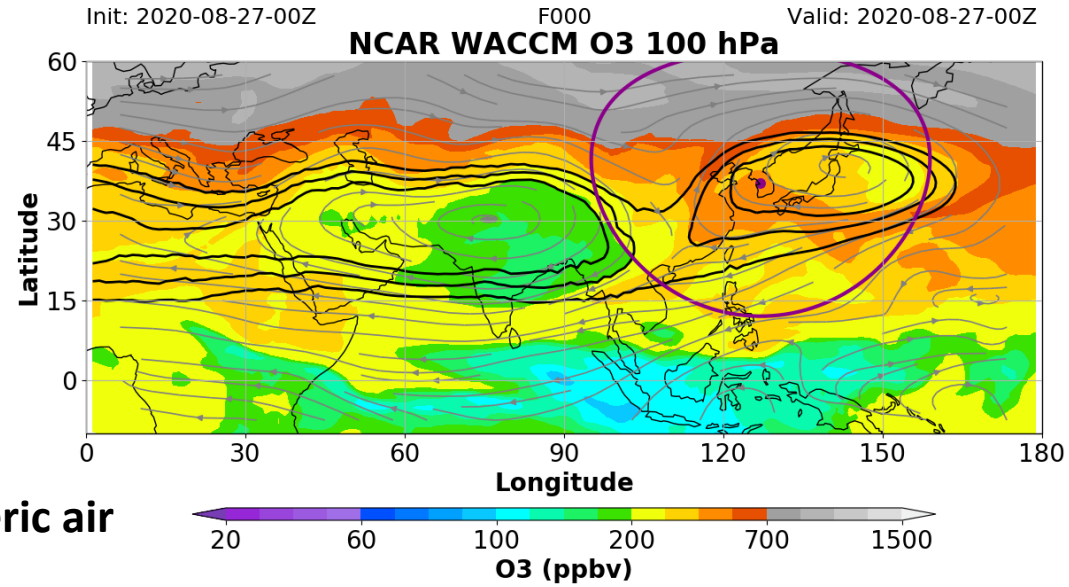
MUSICA

WACCM

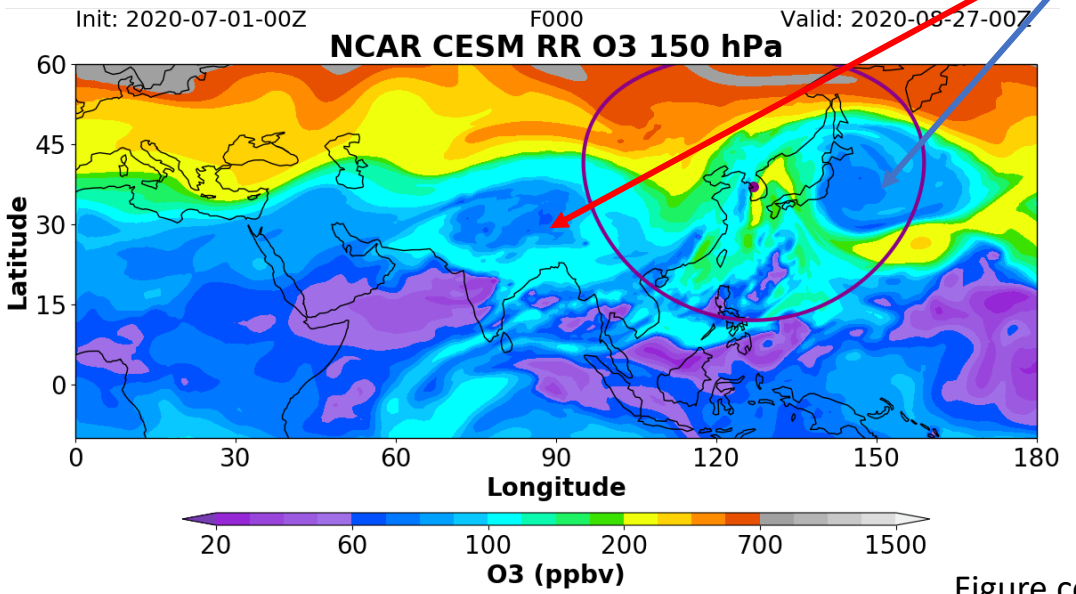
100 hPa

150 hPa





tropospheric air



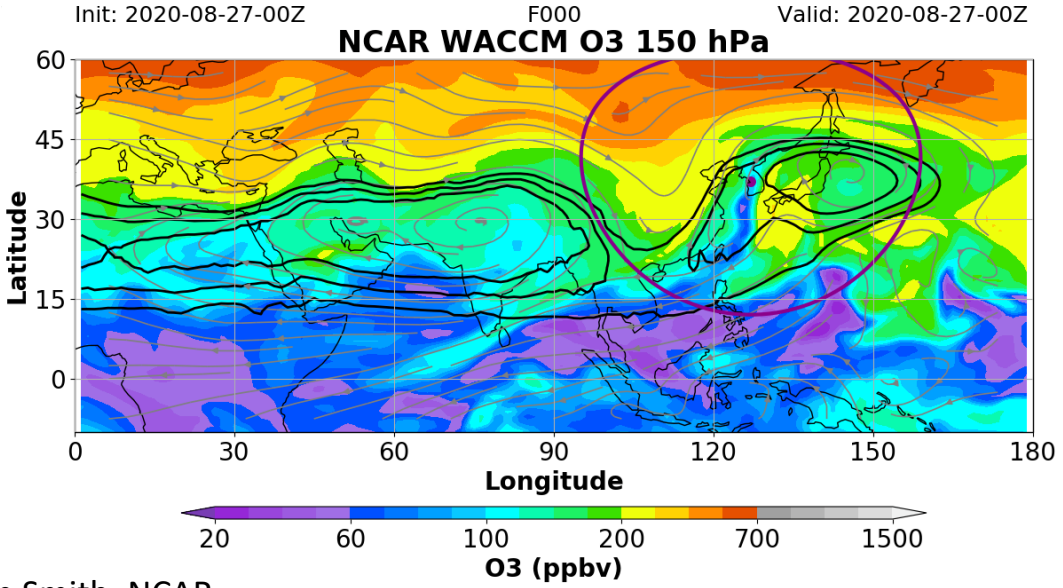


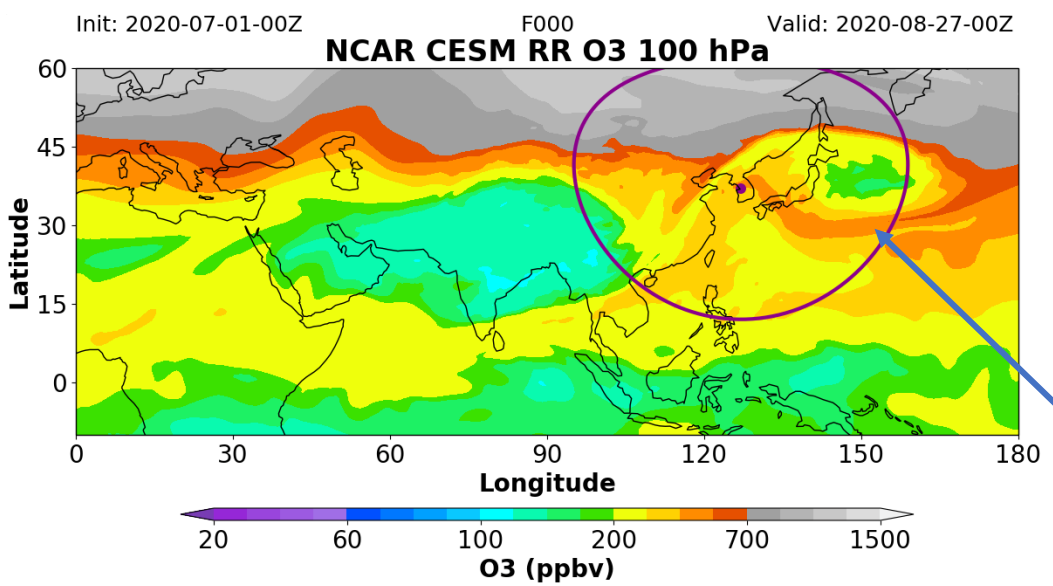
Figure courtesy of Ren Smith, NCAR

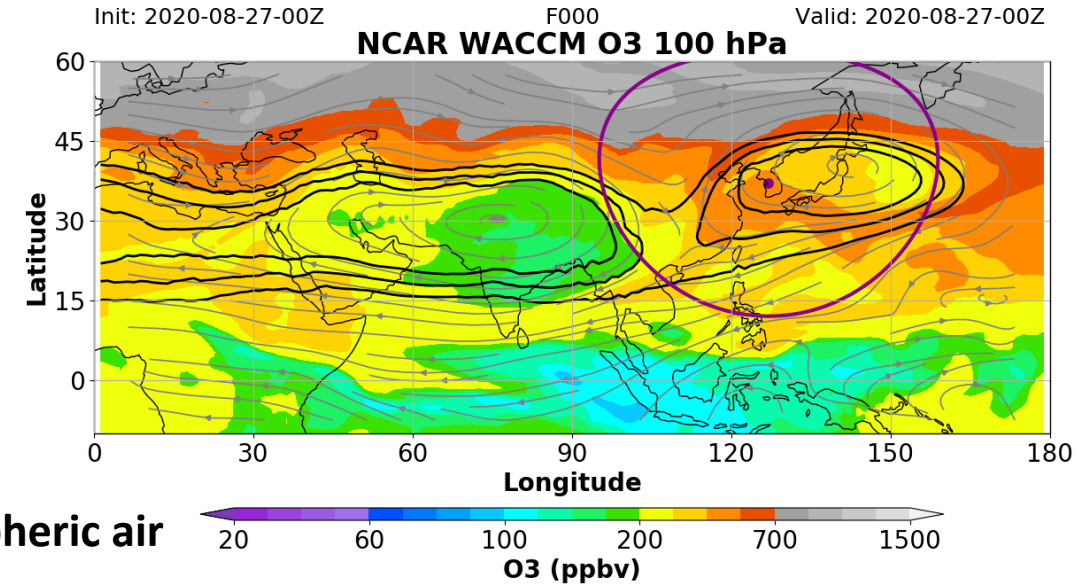
O_3 in the shedding event: Aug 27th, 2020

MUSICA

WACCM

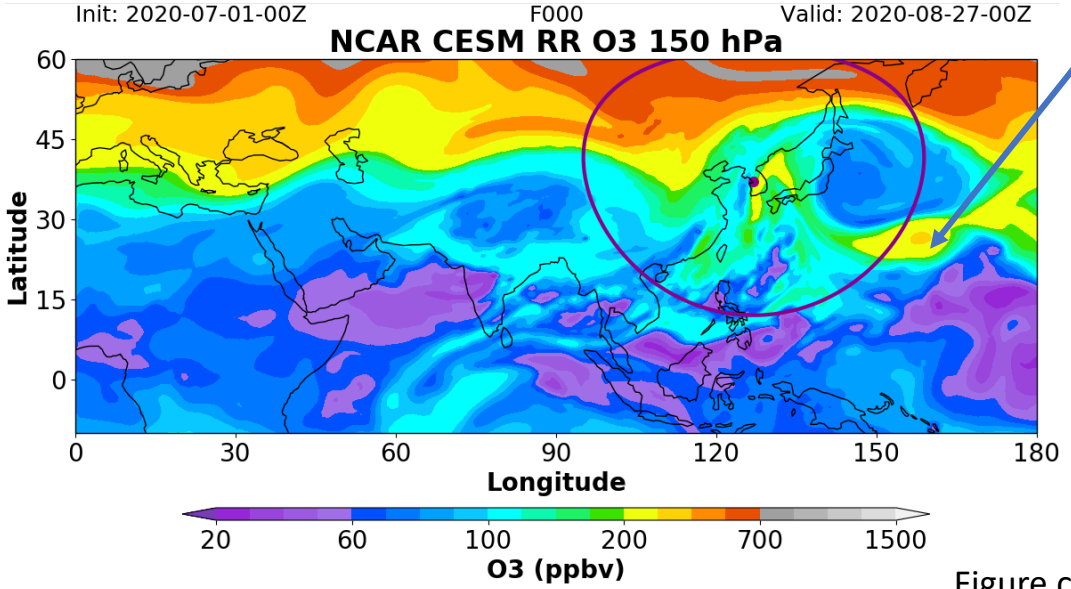
100 hPa





Stratospheric air

150 hPa



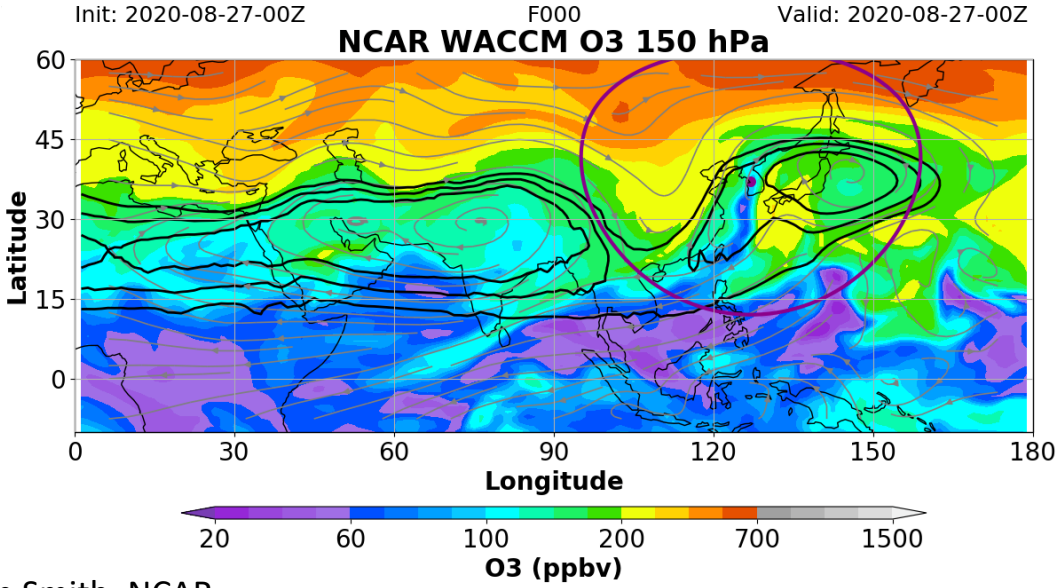
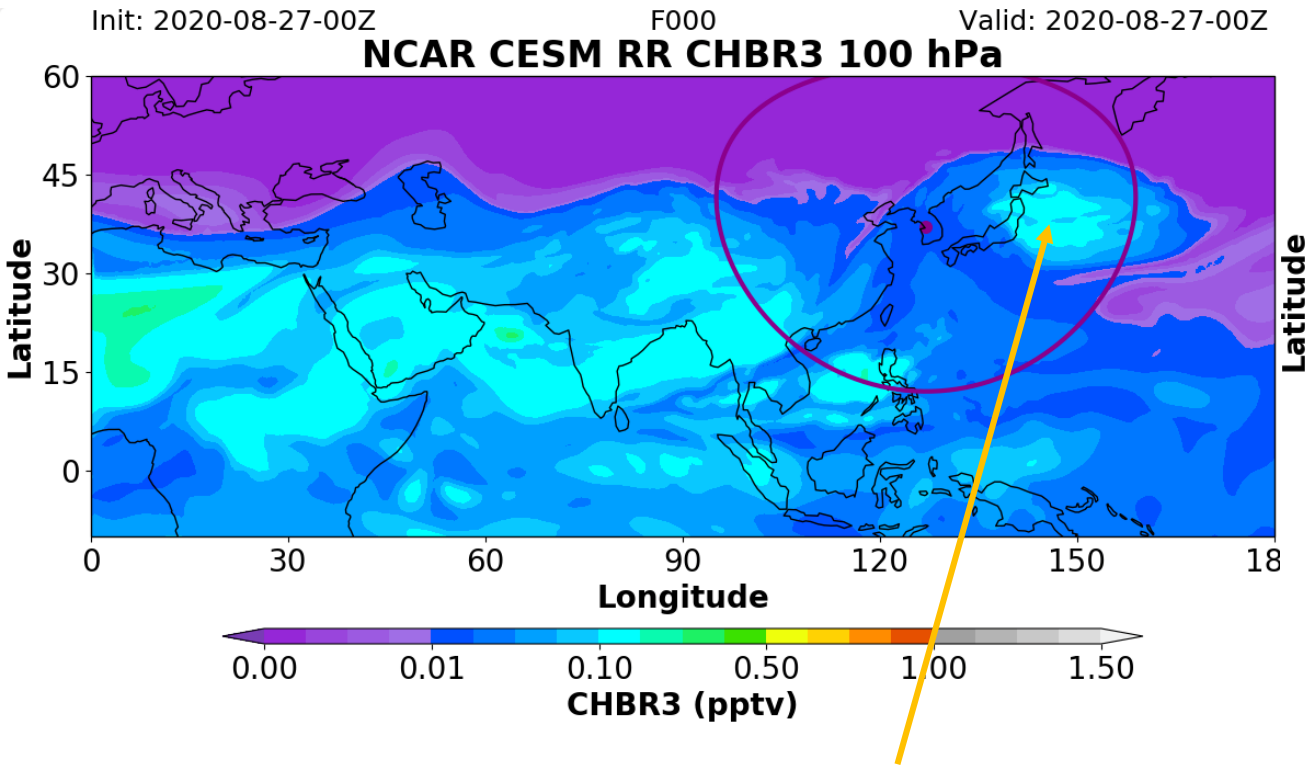


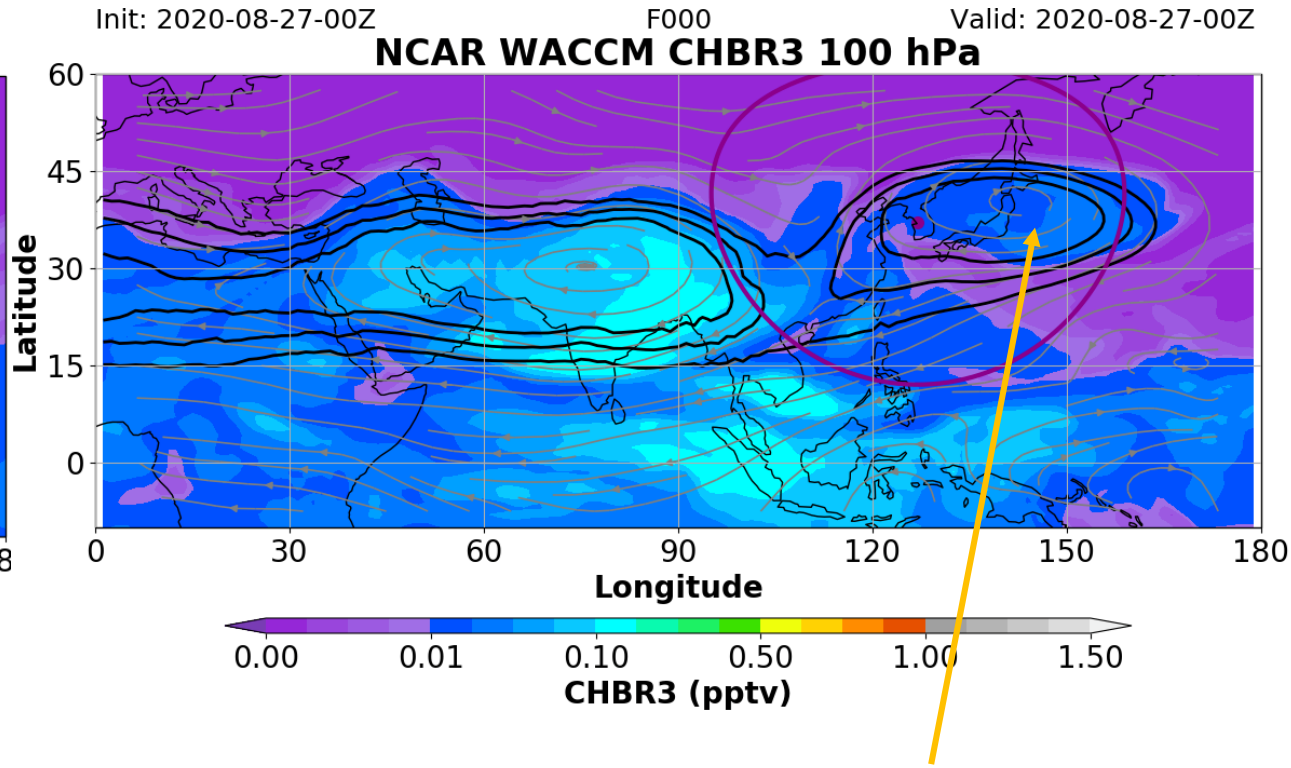
Figure courtesy of Ren Smith, NCAR

Bromoform in the shedding event: Aug 27th, 2020 100hPa

MUSICA



WACCM



Enhanced CHBR3 level – indicating the influence of marine air in the shedding event.

weaker influence.

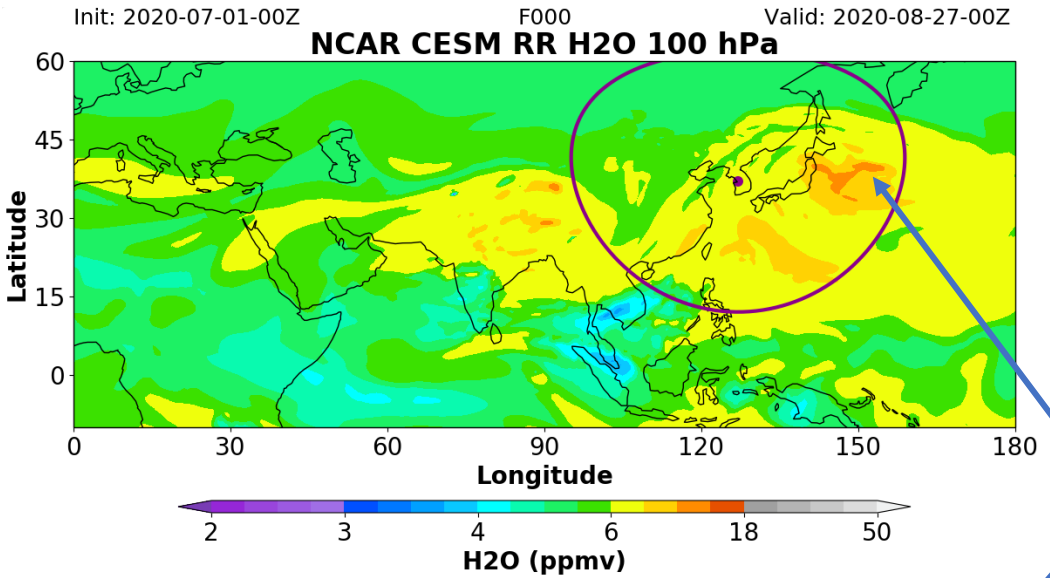
Figure courtesy of Ren Smith, NCAR

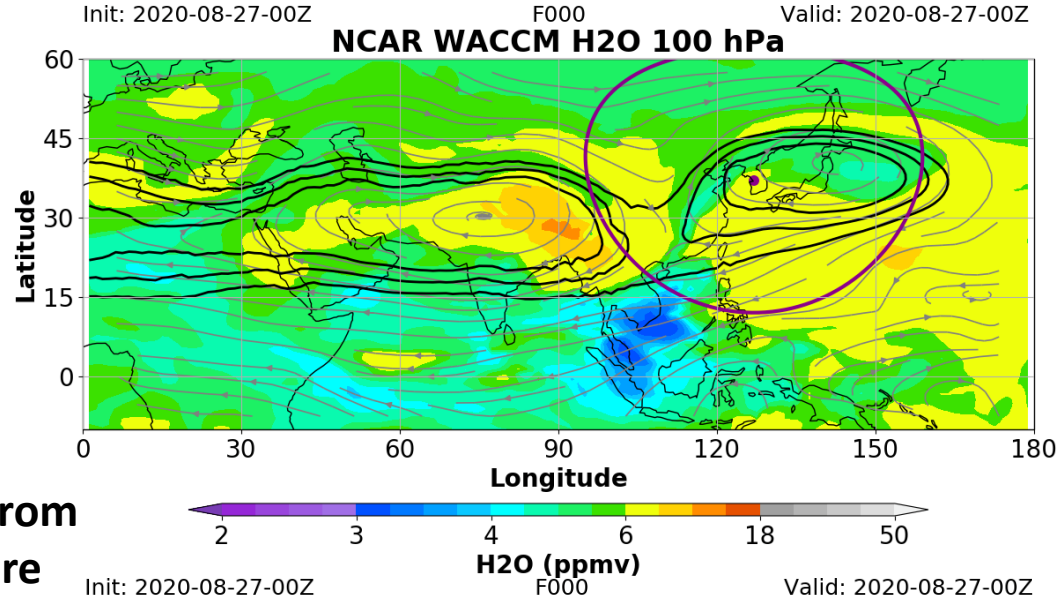
H_2O in the shedding event: Aug 27th, 2020

MUSICA

WACCM

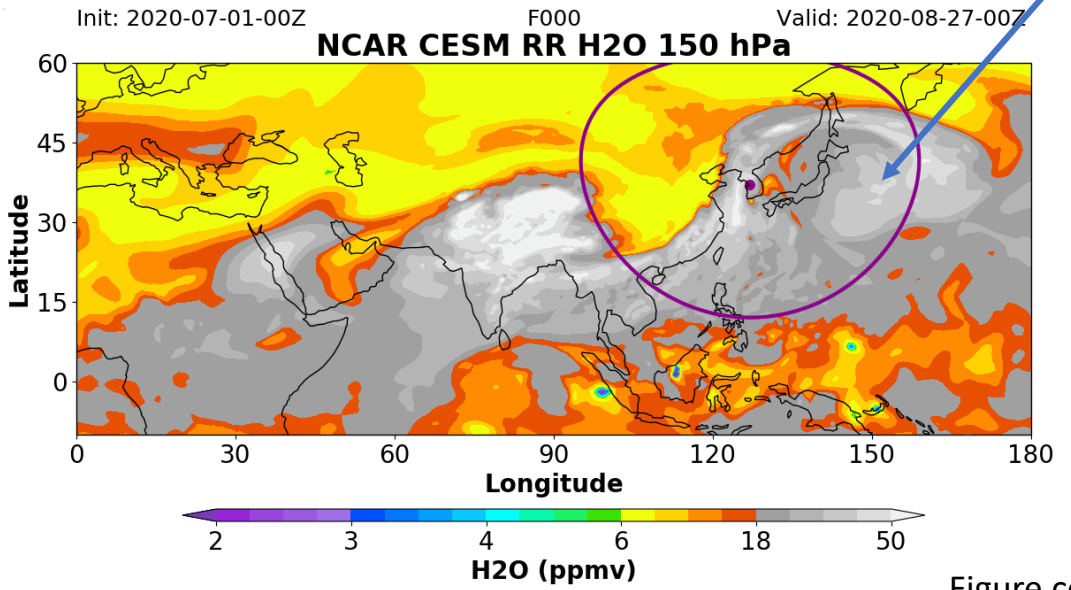
100 hPa





moist air from troposphere

150 hPa



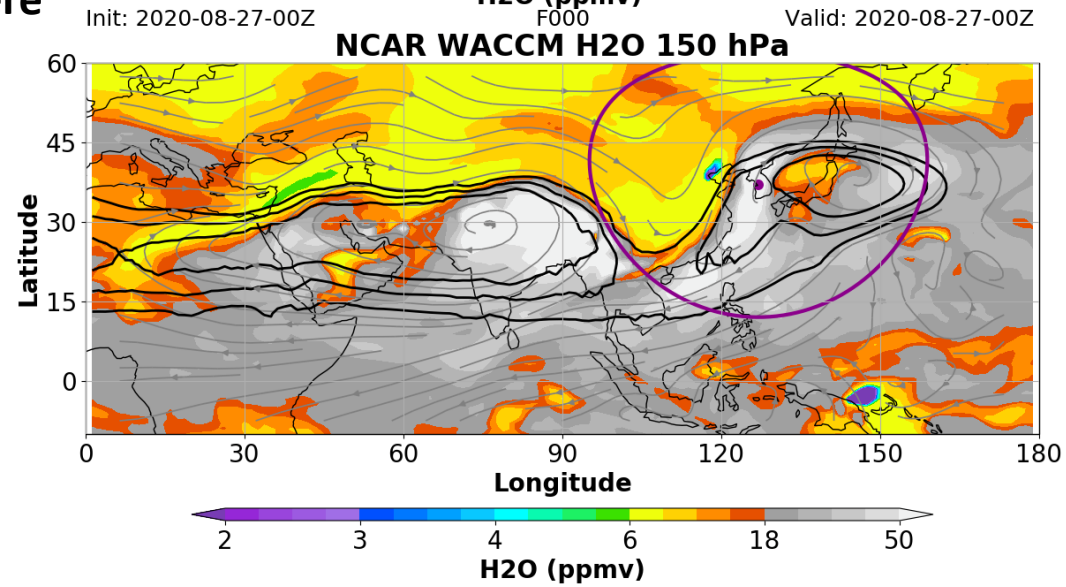


Figure courtesy of Ren Smith, NCAR

Summary

- Successfully running MUSICA with Asia grid for the first time. ☺
- Regional refined CAM6-chem represents the ASM reasonably well, and agrees well with GEOS5 and satellite observations.
- MUSICA is an important tool to study ASM and its chemistry-climate interaction – to support the chemical forecast for ACCLIP Campaign.

First but very important step!

Next step

- Update emissions, this includes new VOC emissions
- Produce new spinup simulation with CO tags and produce new run
- Incorporate more complete halogen chemistry (e.g., iodine chemistry)
- Compare the CAM-chem RR with the CAMchem in 1deg; Test other grids
- Eventually prepare the model for the ACCLIP campaign study

Thanks for your attention.

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Acknowledgement: