Aerosol-induced Dynamical perturbation of the stratosphere: The 2017 Pacific Northwest Pyrocumulonimbus Event

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OBJECTIVE:

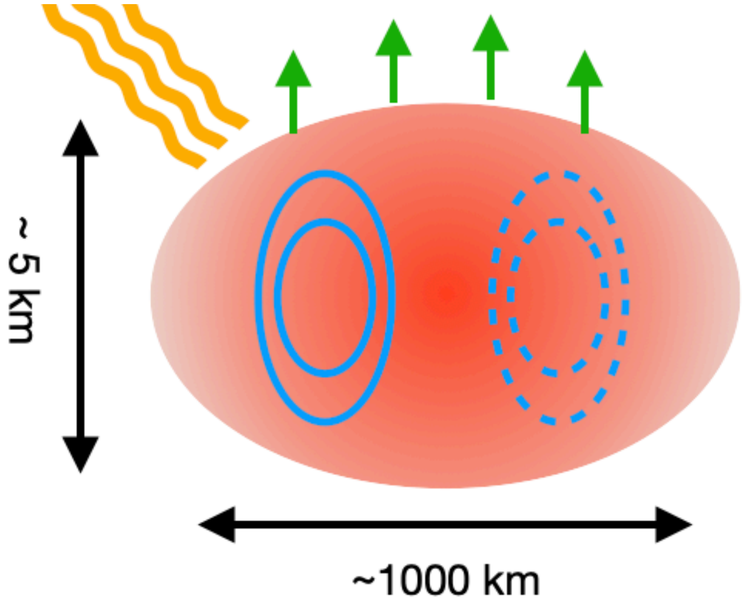
Simulate the dynamical/thermodynamical perturbation caused by the presence of a stratospheric plume of Carbonaceous aerosols

STATE OF THE ART

- **SWIRL: persistent stratospheric anticyclones loaded with aerosols** (ANY Dec 2019-Jan 2020, PNE August 2017)
- Recognized studying observations/reanalyses.

METHODS

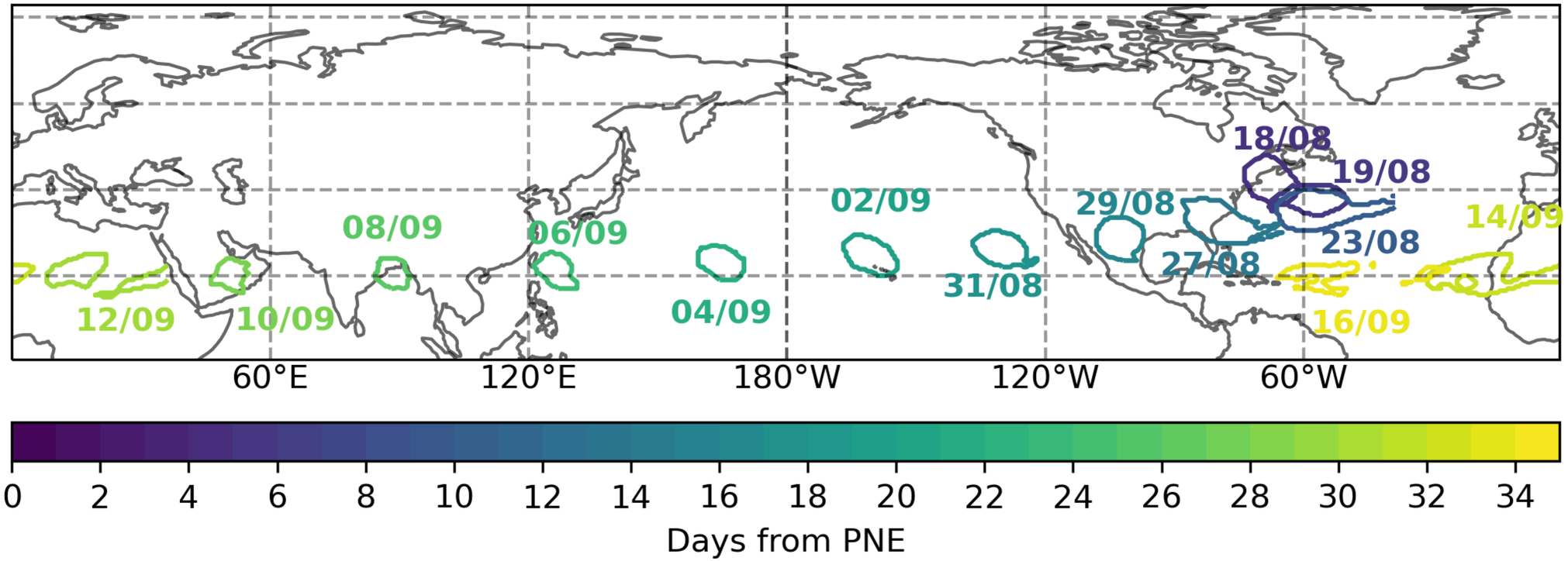
- **GEOS-5 model in the free-running configuration**, 50 days simulation, ~ 50km horizontal grid.
- Stratospheric aerosol injection: **300 ktn, BC+BrC**.
- The **dynamics is influenced by the aerosol radiative heating** (GOCART: Goddard Ozone Chemistry Aerosol Radiation and Transport).



Heating/Aerosol Concentration
Radiation
Diabatic Lofting
Wind (— in - - out)

The model reproduces a stratospheric anticyclone loaded with carbonaceous aerosol

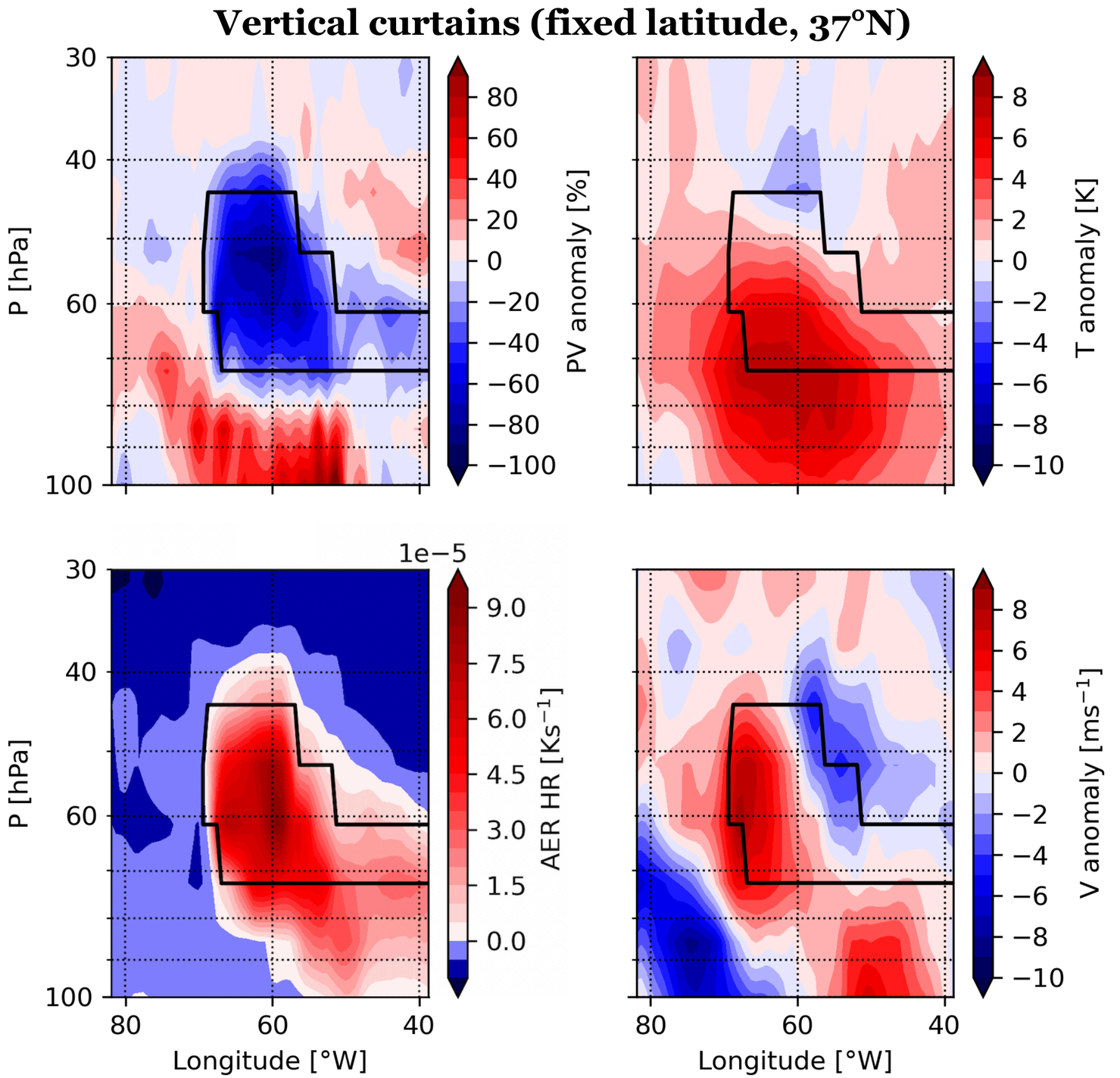
TRACKING THE PERTURBATION



- We track it considering **BrC concentrations** and **PV anomalies** over 100 hPa.
- The anticyclone survives for **25 days.**
- Vertical lofting: **from θ~400 K to θ~600 K.**
- This is not meant to be a faithful simulation of the observed anticyclones since we are **using a free running simulation**.

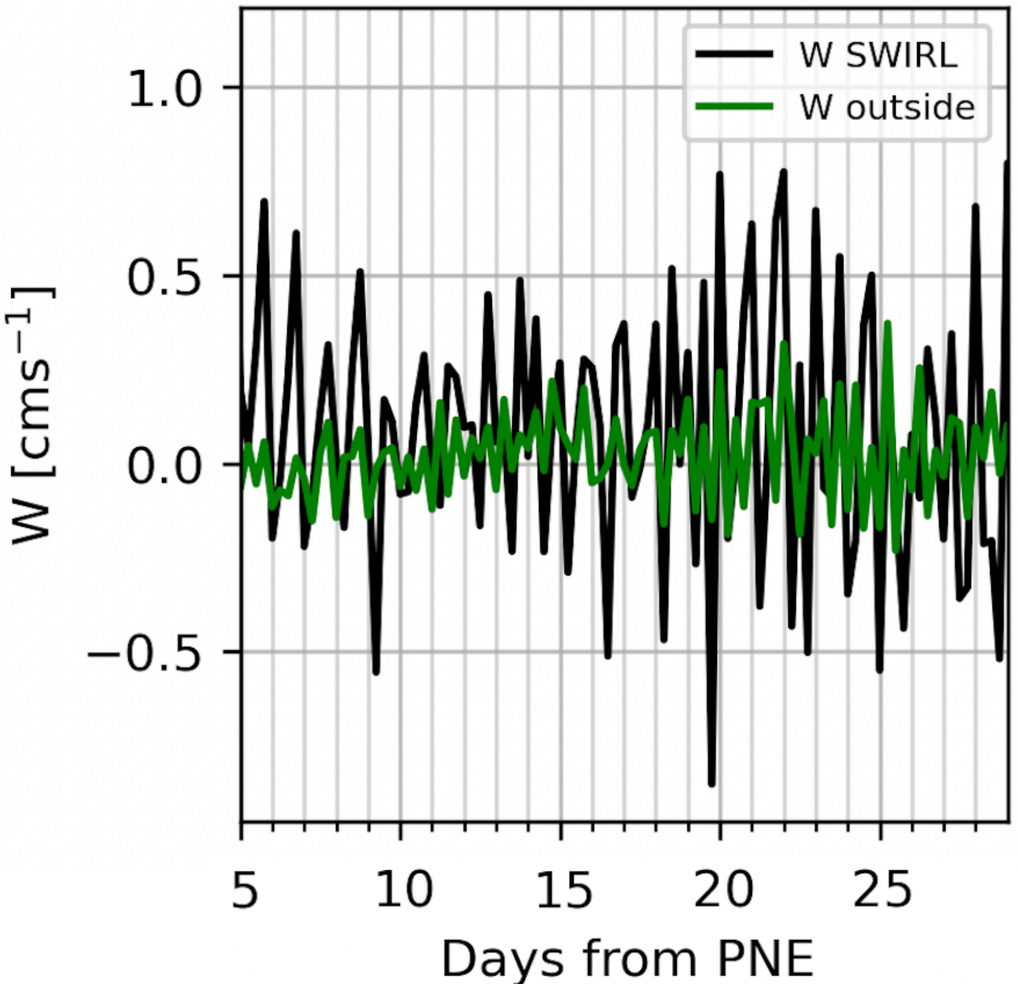
DYNAMICAL SIGNATURES OF THE PERTURBATION (23rd of August,12z)

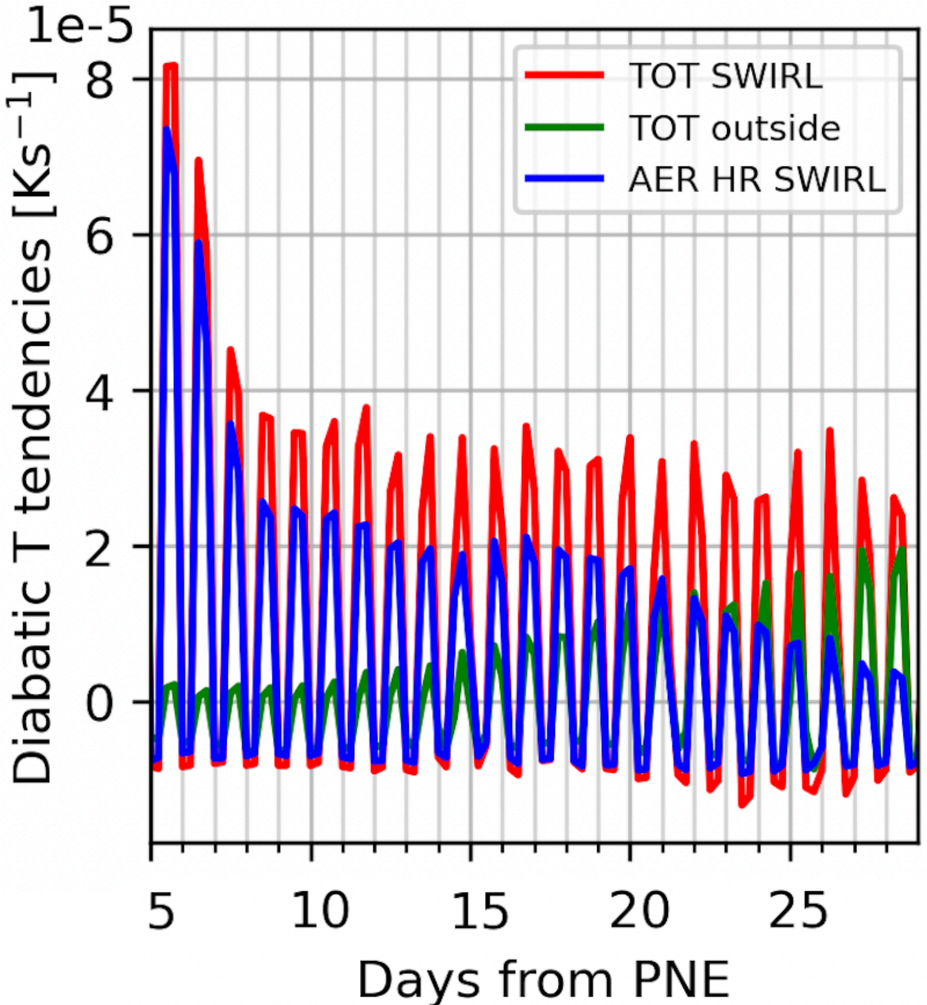
- Negative **PV anomaly**.
- **Temperature anomaly dipole.**
- Vortex structure with tangential velocity of **~10 m/s**.
- **Diurnal heating at the core** of the vortex.
- Sharp edges at the top, presence of **tails at the bottom**.
- At peak volume: **thickness 5 km, diameter ~ 1300 km.**



DYNAMICS OF THE PERTURBATION

- **Diurnal heating** prompts **diabatic lofting and expansion** (coupled with anticyclonic rotation).
- **Nocturnal cooling inverts the process** (however, net ascent).
- **Daily expansion/compression cycle.**
- The perturbation thrives **until the aerosol heating is stronger than the diabatic heating of the background.**





TAKE HOME MESSAGES

- First autonomous simulation of a realistic **stratospheric anticyclonic vortex with aerosol heating accounted for.**
- Evidence of **daily dynamical interaction** between **aerosol heating/vortex evolution.**
- The **presence of the absorbing aerosol is paramount** for the vortex maintenance.

MORE DETAILS IN THE ACPD ARTICLE (PREPRINT):

"Dynamical Perturbation of the Stratosphere by a Pyrocumulonimbus Injection of Carbonaceous Aerosols"

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